NAVAL POSTGRADUATE SCHOOL MONTEREY, CALIFORNIA



THESIS

EVALUATION OF THE BOEING PAN AIR TECHNOLOGIES CODE (A502I) THROUGH PREDICTION OF SEPARATION FORCES ON THE GBU-24

by

Matthew A. LeTourneau

March, 1996

Thesis Advisor:

Max F. Platzer

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EVALUATION OF THE BOEING PAN AIR TECHNOLOGIES CODE (A502I) THROUGH PREDICTION OF SEPARATION FORCES ON THE GBU-24

Matthew A. LeTourneau
Lieutenant, United States Navy
B.S., The George Washington University, 1988

Submitted in partial fulfillment of the requirements for the degree of

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from the

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ABSTRACT

The Boeing PAN AIR Technologies code (A502i) is investigated to explore its suitability for determination of separation forces on ordnance. To this end, A502i is first assessed by applying it to three problems for which other solutions and experimental data are available, i.e. steady flow past a rectangular, parabolic arc wing and a delta wing at both subsonic and supersonic conditions. Good agreement is found in all cases. A502i is then applied to the GBU-24's being in two configurations for a subsonic case and a supersonic case. Good agreement is found with data obtained from wind tunnel experiments for low angles of attack.

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I. INTRODUCTION

In the past, ballistic trajectory determination for manual or computer predicted ordnance delivery from an aircraft was determined through measurement of separation forces on the piece of ordnance via wind tunnel or captive carry measurements. The advent of panel method codes using linearized potential theory, such as A502i, or its full potential version TranAir, allow for a cheaper and safer method of predicting separation forces. Furthermore, A502i allows for any arbitrary configuration to be modelled within the limitations of the number of panels and networks allowed and excluding transonic flow.

The purpose of this work was to determine the separation forces on a GBU-24 carried by an F-14 on stations 3 or 6 or both. It was also the purpose of this work to provide an analysis of the code itself to see if it is a viable tool for the study of flow characteristics over arbitrary wing configurations for use in the Naval Postgraduate School's (NPS) Department of Aeronautics and Astronautics. The majority of the work was conducted on the NPS computer systems. The Department of Aeronautics and Astronautics Silicon Graphics Incorporated (SGI) workstations were utilized for most of the input files as well as the execution of the code. Due to the amount of disk space required, storage of the output files took place on the NPS Computer Center's Y-MP EL98 Cray computer. The bulk of the GBU-24 data was calculated using the SGI workstations at the Naval Air Warfare Center in Warminster.

The scope of this analysis was to understand the capabilities of the A502i code. The approach was to validate A502i against existing data and linear theory. The code was run for three different geometries under assorted Mach and AOA conditions. Comparisons were made for each of the geometries.

II. OVERVIEW OF THE A502i CODE

The A502i code is used to computationally analyze inviscid subsonic or supersonic flows about arbitrary configurations. The code differs from other panel methods in that it is a higher order panel method; that is, the singularity strengths are not constant on each panel. A502i solves the linearized potential flow boundary-value problem at subsonic and supersonic Mach numbers.

The aerodynamic solution provides surface flow properties (flow directions, pressures, Mach number), configuration forces and moments, sectional forces and moments, and pressures. Additionally, A502i calculates flow properties in the flow-field points and flow-field streamlines. Results are limited to subsonic and supersonic cases (transonic cases excluded) with attached flow. Results are not usually applicable to cases where viscous effects and separation are dominant.

A. THEORY

The basic equations describing the flow of a viscous, compressible, heat-conducting fluid are the Navier-Stokes equations. These are:

(a) The continuity equation,

$$\frac{\partial \rho}{\partial t} + \nabla \bullet (\rho \vec{\mathbf{V}}) = \frac{\partial \rho}{\partial t} + \sum_{i=1}^{3} \frac{\partial (\rho \mathbf{V}_{i})}{\partial x_{i}} = 0$$
 (2.1)

where $\nabla = (\frac{\partial}{\partial x_1}, \frac{\partial}{\partial x_2}, \frac{\partial}{\partial x_3})$ is the gradient operator with respect to the location vector $\vec{x} = (x_1, x_2, x_3)$, and where the conventional index notation is used instead of $\vec{x} = (x, y, z)$. In addition, t is time, $\rho(\vec{x}, t)$ is the density and $\vec{V}(\vec{x}, t)$ is the velocity vector, with components $\vec{V} = (V_1, V_2, V_3)$.

(b) The conservation of momentum equation,

$$\frac{\partial}{\partial t}(\rho V_j) + \sum_{i=1}^{3} \frac{\partial}{\partial x_i}(\rho V_i V_j) = \frac{-\partial p}{\partial x_j} + \sum_{i=1}^{3} \frac{\partial}{\partial x_i} \tau_{ji} + \rho f_j \quad (j = 1, 2, 3)$$
(2.2)

where τ_{ij} is the deviatoric portion of the stress tensor which vanishes for a frictionless fluid, $\vec{f}(\vec{x},t)$ is an external body force per unit mass exerted on the fluid, and $p(\vec{x},t)$ is the pressure.

(c) The conservation of energy equation

$$\frac{\partial}{\partial t} (\rho e + \frac{1}{2} \rho |\vec{V}|^{2} + p) + \sum_{i=1}^{3} \frac{\partial}{\partial x_{i}} [(\rho e + \frac{1}{2} \rho |\vec{V}|^{2} + p)V_{i}]$$

$$= \frac{\partial p}{\partial t} + \sum_{i,m} \frac{\partial}{\partial x_{i}} (\tau_{im} V_{m} + k \frac{\partial T}{\partial x_{i}}) + \rho \sum_{i} f_{i} V_{i}$$
(2.3)

where $e(\vec{x},t)$ is the internal energy of the fluid, k is the coefficient of heat conductivity for the fluid, and $T(\vec{x},t)$ is the temperature.

(d) The equation of state

$$f(\rho, p, T)=0$$
 (2.4)

where the function f depends on the type of fluid. The derivations of these equations can be found in Refs. 1,2 and 3.

The Navier-Stokes equations can be simplified by the neglect of viscosity, which is equivalent to setting the deviatoric stress tensor to zero. Combining the momentum and continuity equations yields

$$\rho \frac{dV_j}{dt} = -\frac{\partial p}{\partial x_i} + \rho f_j \quad j = 1, 2, 3$$
 (2.5)

where the convective derivative operator is defined as

$$\frac{\mathrm{d}}{\mathrm{d}t} = \frac{\partial}{\partial t} + \sum_{i} V_{i} \frac{\partial}{\partial x_{i}}$$

Equation (2.5) is referred to as Euler's equation. The continuity and energy equations can

Equation (2.5) is referred to as Euler's equation. The continuity and energy equations can be reduced to

$$\rho \frac{\mathrm{d}}{\mathrm{dt}} \left(\frac{1}{2} \left| \vec{\mathbf{V}} \right|^2 \right) = -\vec{\mathbf{V}} \cdot \nabla \mathbf{p} + \rho \vec{\mathbf{V}} \cdot \vec{\mathbf{f}}$$
 (2.6)

and the rate of increase of heat per unit mass is given by

$$q = \frac{1}{\rho} \nabla \cdot (k \nabla T) = \frac{d\rho}{dt} + p \frac{d}{dt} \left(\frac{1}{\rho}\right)$$
 (2.7)

Equations 2.5, 2.6 and 2.7 can be reduced to a single equation when four further assumptions are made. First, assume isentropic flow, thus

$$q=0$$
 (2.8)

Second, assume irrotationality

$$\nabla \,\mathbf{x}\,\vec{\mathbf{V}} = 0 \tag{2.9}$$

which allows for the introduction of the potential function [Refs 2,3]

$$\nabla \Phi = \vec{V} \tag{2.10}$$

Third, assume the existence of a freestream potential Φ_∞ , whose gradient is the uniform velocity \vec{V}_∞ attained at points sufficiently distant from the disturbance being analyzed, and thus write

$$\phi = \Phi - \Phi_{\infty} \tag{2.11}$$

and

$$\vec{V} = (u, v, w) = \nabla \Phi = \nabla \Phi_{\infty} + \nabla \phi = \vec{V}_{\infty} + \nabla \phi$$
 (2.12)

The quantities ϕ and \vec{v} are called the perturbation potential and velocity [Ref 3]. Fourth, assume that

$$\left|\vec{\mathbf{v}}\right|^2 \ll \mathbf{a}_{_{\infty}} \tag{2.13}$$

everywhere, where a sis the freestream speed of sound.

Based on these four assumptions, the unsteady potential equation is obtained [Refs 1,3]:

$$(1 - M_{*}^{2})\phi_{xx} + \phi_{yy} + \phi_{zz} - 2M_{*}^{2}\phi_{xt} - M_{*}^{2}\phi_{tt}$$

$$= M_{*}^{2} \left[\frac{1}{2} (\gamma - 1)(2u + 2\phi_{t} + |\vec{v}|^{2}) \nabla^{2}\phi + (2u - u^{2})\phi_{xx} + v^{2}\phi_{yy} + 2vw\phi_{yz} + w^{2}\phi_{zz} + 2(1 + u)(v\phi_{xy} + w\phi_{xz}) + 2(uu_{t} + vv_{t} + ww_{t}) \right]$$

$$(2.14)$$

Assuming the flow conditions do not change with time yields the steady non-linear potential equation.

$$(1 - M_{x}^{2})\phi_{xx} + \phi_{yy} + \phi_{zz}$$

$$= M_{x}^{2} \left[\frac{1}{2} (\gamma - 1)(2u + |\vec{v}|^{2}) \nabla^{2} \phi + (2u + u^{2})\phi_{xx} + v^{2}\phi_{yy} + 2vw\phi_{yz} + w^{2}\phi_{zz} + 2(1 + u)(v\phi_{xy} + w\phi_{xz}) \right]$$

(2.15)

When $M_x=0$, equation (2.15) reduces to Laplace's equation,

$$\nabla^2 \phi = 0 \tag{2.16}$$

For the case of $M_{\infty} \neq 0$, the following is supposed,

$$M_{r}^{2} |\vec{v}| \ll 1 - M_{r}^{2} \tag{2.17}$$

$$\mathbf{M}_{\perp}^{2} |\vec{\mathbf{v}}| \ll 1 \tag{2.18}$$

which are small perturbation assumptions [Refs. 1,2]. With these assumptions the steady non-linear potential equation reduces to the Prandtl-Glauert equation [Ref 1]:

$$(1 - M_{\infty}^{2})\phi_{xx} + \phi_{yy} + \phi_{zz} = 0$$
 (2.19)

Through a coordinate transformation [Refs. 1,2,3], the Prandtl-Glauert equation can be rewritten as:

$$S\phi_{\tilde{x}\tilde{x}} + \phi_{\tilde{x}\tilde{y}} + \phi_{\tilde{z}\tilde{z}} = 0 \tag{2.20}$$

where when s=1, it is the subsonic case and Laplace's equation applies and when s=-1, it is the supersonic case and the wave equation applies. Applying Green's third identity [Ref. 1] yields the following integral equation,

$$\phi(P) = -\frac{1}{4\pi} \iint \left[\frac{\sigma}{R} - \mu \hat{\mathbf{n}} \cdot \nabla \frac{1}{R} \right] dS$$
 (2.21)

where σ represents the source strength and μ represents the doublet strength. When supplemented with boundary conditions, it is equation (2.21) that A502i solves.

A502i solves equation (2.21) through a discretization process. The general idea of the process falls into two parts. The first is developing finite dimensional approximate representation formulas for the singularity functions, which creates a system of equations with unknown coefficients, λ_i . The second part involves solving the set of equations for all λ_i . This allows for completely determining the source and doublet functions. Then, by virtue of equation (2.21), the potential function $\phi(P)$ is determined for all points P, solving the problem.

The features of A502i which distinguish it from predecessors are three-fold. The first is a feature known as "continuous geometry", the second is linear source and quadratic doublet variation, the third is continuity of doublet strength.

Most panel methods approximate the configuration geometry with panels whose planform is a quadrilateral. Thus, if the panels themselves are planar, only a small class of configurations (such as cylinders and flat wings) can be described without gaps being left between panels. These gaps are generally small, except for highly twisted surfaces. The

gaps cause little numerical error in subsonic flow, but in supersonic flow, the cumulative effect of the gaps is serious [Ref. 1]. The problem is not associated with leakage of flow through the gaps, but with the doublet strength jumping abruptly from a non-zero value to zero at a panel edge which does not exactly meet the adjacent edge. In A502i, gaps are closed by means of panels which are comprised of several planar regions.

The feature of linear source and quadratic doublet variation is what makes A502i a higher order panel method. The basis function corresponding to a source parameter is locally linear, while the basis function corresponding to a doublet parameter is locally quadratic. This is what allows for A502i to find supersonic solutions. Numerical solution of the wave equation is far more sensitive to the numerical idiosyncracies of a panel method than is the solution of Laplace's equation for subsonic flow. Experimental evidence [Ref. 1] indicates that exact surface analysis is not feasible in supersonic flow without doublet continuity, thus the potential for numerical error is greatly reduced by requiring the doublet singularity strength to be continuous across panels.

B. GENERAL A502i USAGE

The use of the A502i code consists of generating an input file, which can be arbitrarily named, and which contains the information defining the geometry of the configuration, flow field points of interest, the flow conditions and wakes. The process of building a geometry is difficult in that A502i is particular about its input format. Simple configurations, such as a rectangular, planform wing can be modelled manually, but more complex structures require a pre-processing program, such as MACGS, where a geometry can be graphically built. MACGS will output a data file in a format that, with minor modifications, via another pre-processing program that can move the data from three columns to six columns, will be readily usable by A502i. Currently, the school does not have a copy of MACGS, but it can be acquired through McDonnell-Douglas. To complete

this thesis, MACGS was used on the SGI workstations at NAWC Warminster. Wakes also must be constructed in the same manner as the structure to be analyzed. More detailed instructions on the specifics of wakes and surface geometries can be found in Ref. [4]. Appendix A is a portion of an output file, but lines 1 thru 1120 are an exact duplicate of the input file.

1. Running A502i with an Existing Executable

Assuming an A502i executable file (e.g., A502) has already been placed in a user executable directory (e.g., /usr/local/bin), the only other necessary items needed to produce a set of A502i output files is the input file and a large amount of storage space. Anything modelled with more than one thousand panels total will use more than one hundred mb of disk space. If the maximum number of panels (20,000) is used, the disk space required will be on the order of 2 gb.

To run A502i, enter after the UNIX prompt:

A502 <input file > output file

Prior to running the code, it is highly recommended that a Cray account be opened and linked to the department's SGI workstations. This is done by assigning the same user i.d. number to the Cray account as is assigned to the account with the department. User i.d. numbers can be changed by the computer center at the user's request. This is required due to the limited disk space available to individual accounts in the department. Once an account is opened, log on to a department workstation, change directories to an existing Cray directory, for example (after the UNIX prompt):

cd /jedi/d1/maletour

Transfer the input file to the Cray directory and execute the code. The screen will display what portion of the code it is performing and how long it took to perform each portion in CPU time. The code outputs numerous files in addition to the arbitrarily named output file.

The two output files of interest, in the vast majority of cases, are the arbitrarily named output file and the ft13 file. In order to run another solution all output files must be deleted or renamed prior to re-executing the code. Relevant results should not be kept on the Cray account as files on disks d1, d2 and u1 are considered temporary storage and subject to erasure after a period of time.

2. Creating an A502i Input File

The input file, which can be arbitrarily named, consists of two portions, the largest being the geometry data. Appendix A is a complete recreation of the input file for the GBU-24 with canards. The file begins with line 1, \$TITLE, and ends with line 1120, \$END. The line numbers are for reference only and are not part of the actual input file. The first portion consists of creating the initial conditions, i.e., the free-stream Mach number and angle of attack, the type of analysis to be performed, i.e., solution or datacheck, what types of output that are to be included in the arbitrarily named output file, and reference points to be used in calculating forces and moments. The geometry data consists of the points that bound each panel, that in turn belong to a specific group of panels that make up a network. The overall structure being modelled consists of a series of networks. A502i can run up to 150 networks and or 20,000 panels with a limit of 8,000 panels per network. Referencing Appendix A, line 28 represents the first network of the model, a canard. Line 29 represents the number of networks that will be classified under this \$POINTS statement. Line 30 indicates what kind of surface the network will be, a three-dimensional surface with flow properties to be calculated, a wake and a base are several examples. Line 31 is the number of y points and the number of x points respectively that make up the grid of that network. Line 32 is where the panel points start. Reference 4 contains detailed instructions on the options and meaning of each of the nongeometry inputs, including some capabilities not shown in Appendix A.

Two types of solutions can be run, a datacheck and a full solution. Reference 4 explains how to enter either one into the input file. The datacheck only analyzes the geometry. This can be accomplished in a matter of seconds for a simple geometry as it is only running the first several portions of the code. The full solution can take a couple of hours for a geometry of the size of 4,000 panels. The datacheck should be run once the geometry has been modelled. It will check for any panel edges that do not abut properly, and when column 4 of line 20 in Appendix A is a 1, the datacheck will list the unit normal vectors, which must be facing outward. The datacheck will also see if the wakes are attached properly. A502i is capable of giving warnings both on-screen and in the arbitrarily named output file when an edge or a wake is not modelled properly, but it only lists the unit normal vectors. The directions of the vectors must be manually checked by the user. The full solution performs the datacheck first, so the data is repeated in the arbitrarily named output file. Appendix B is a portion of the output file that contains the summary of facing surfaces. Each panel edge is looked at to see what it abuts against. Sections such as wingtips, leading edges of a flat plate or any surface that does not need a wake attached, but is unabutted to any other panel on that edge will draw probable error messages or warnings from the code. The user must ensure that the edge is not supposed to abut against anything or need a wake attached. If that is the case, the warnings may be ignored. Appendix D is the first page of the portion of the output file that lists the unit normal vectors. The three columns under zc are the x-y-z coordinates of the given panel's center. The three columns under znc are the x-y-z coordinates of the unit normal vector. In most cases, when the y coordinates are of the same sign, then the unit normal vector is pointing outward.

C. GEOMETRY MODELLING

Five geometries needed to be modelled, each of increasing complexity. Modelling proved to be the most difficult task, in that A502i is a FORTRAN code and is very format sensitive, but the sheer number of points that need to be generated can take a lot of time and the order those points are listed in the input file is what determines whether or not the shape is correctly modelled. Of the five geometries modelled, none were done completely manually. A spreadsheet was used for generating the parabolic arc airfoil and the deltawing since those structures can be constructed out of one network, excluding wingtips and wakes, and the surface can be defined by a mathematical function. The bombs and the F-14 required the use of MACGS to be properly modelled. MACGS is indifferent as to the order that geometries are built, and often doesn't require many coordinate inputs if building a model on top of an existing IGS file. The output file from MACGS is automatically formatted and the points placed in the appropriate order for A502i to understand. Although, the order may be reversed where the unit outward normal vector is concerned. MACGS has the ability to output files in several different panel method code input formats, including PMARC. Reference 4 gives detailed instructions on how to properly order points to build a group of networks that will model a geometry. A502i uses a right-handed coordinate system that is similar to an aircraft body axes. When put in terms of a wing, the x axis is positive from leading edge to trailing edge. The z axis is positive up and the y axis is positive out the right wing

1. The Parabolic Arc Airfoil

The parabolic arc airfoil is the simplest of all the geometries. The airfoil has a chord of five and a span of ten. The maximum thickness is .15. The model consists of approximately 600 panels, including the wake and wingtips. A spreadsheet was used to develop the geometry portion of the input file. Line 32 of Appendix A demonstrates the

format that the spreadsheet used. Rows consist of two points, with coordinates x1, y1, z1, x2, y2, z2 using a format of 6F10.0. The chord was divided into 25 points (x coordinate) from trailing edge to leading edge and then another 25 points from leading edge to trailing edge (bottom half). The span was divided into 12 points (y coordinate) from left to right. Due to the symmetry of a rectangular planform, the y coordinate was constant along the 50 x coordinates that constituted a chordwise cross-section. To attain a maximum thickness of .15 the formula,

$$z = .3 * (\frac{x}{c} - \frac{x}{c^2})$$
 (2.22)

was utilized to generate the values of the z coordinates. The wingtips simply connect the x coordinate on the top side with it's symmetrical counterpart on the bottom side. Due to a trailing edge composed of a straight line, the wake is modelled by a single panel that spans the trailing edge and has a length aft of 100. Figure 2.1 shows the panel distribution across the top surface of the parabolic arc airfoil, where the thickness is represented by the color scheme. A panel and a point are numbered to show how they were entered into the input file.

2. The Deltawing

The deltawing represented a step up in complexity over the parabolic arc airfoil. The chordwise cross-section is parabolic, while the spanwise cross-section is linear. The procedure for building the geometry on a spreadsheet was the same as that for the parabolic arc airfoil, only the chord length is not constant along the span. For simplicity in design, the number of panels per column of panels is constant on the deltawing, as on the parabolic arc airfoil. This means an increasing panel density in the direction of the wing tip. The wake is modelled the same as the airfoil. The right wingtip ended in a point, so no extra panelling was needed to close any gaps. The symmetry of the deltawing allowed for



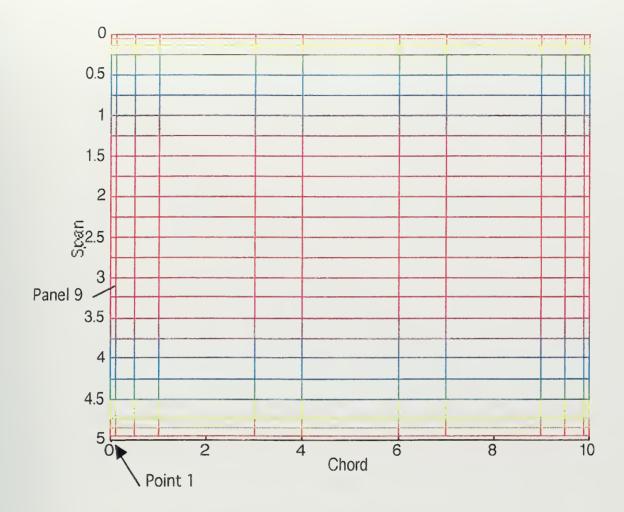


Figure 2.1 Parabolic Arc Panel Distribution

further simplification and reduction of the code's run time by only modelling from the centerline to the right tip. A502i allows the user to stipulate whether there is symmetry in the x-z plane and or the x-y plane (see line 5 and 6 of Appendix A). This means that the gap between the top and bottom panels at the center line does not need to be bridged as in the parabolic arc airfoil (symmetry could have also been used in the airfoil's case). The chord of the deltawing has a length of 90 and the semi-span has a length of 15. The maximum thickness occurs midway along the centerline and is .05. The model consists of 880 panels. Figure 2.2 shows the panel distribution along the top surface of the deltawing.



Thickness is represented by the color scheme.

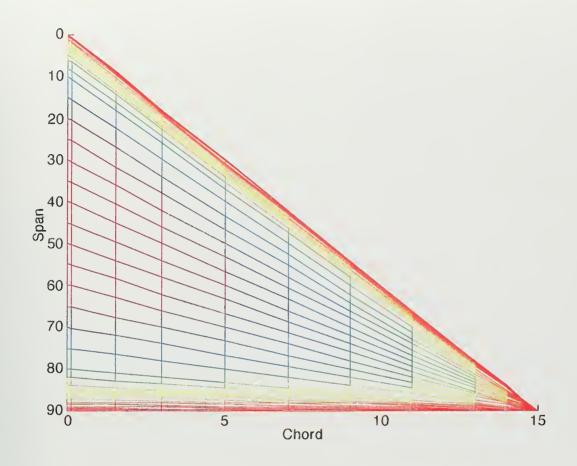


Figure 2.2 Panel Distribution of Deltawing

3. GBU-24

Wind tunnel experiments were run on the GBU-24 without canards attached, so it was deemed relevant to build a model with and without canards as a comparison of the code's performance. The model of the GBU-24 was too complex to build with a spreadsheet, so MACGS was used. The bomb was modelled at NAWC Warminster by superimposing a group of networks on top of an IGS file being displayed by MACGS. The complete configuration consists of approximately 1300 panels. Figures 2.3 and 2.4 are displays of the GBU-24 with canards, with Figure 2.4 including the wakes. Figure 2.5



is included to show how the GBU-24 model was assembled. Each different color represents a network.

Several features of the geometry are relevant to point out. Two of them are modifications made to the geometry that differ from the actual dimensions of the bomb. Dr. Alex Cenko of NAWC Warminster has extensive experience with modelling stores in A502i. The modifications were made on his knowledge of how to get the most accurate results from the code when modelling stores. The first is to model the fins and canards as flat plates, i.e., no thickness, which A502i allows you to do through a single numerical change in the input code for each network that represents a flat plate (see line 30 of Appendix A). The fins and canards are extremely thin when compared to the rest of the bomb, and to add a third dimension to the geometry complicates the construction of the fin or canard for several reasons. The leading and trailing edges must be sharp and the surface the fin or canard attaches to would have to be modified to abut properly with two edges instead of one. Experience has shown that the simpler version yields accurate predictions. A502i is an inviscid code, so it cannot take into account separation effects on its own. The GBU-24 does not have a flat base. In reality, it is more bullet nosed in shape. However, at the speeds with which the bomb is being analyzed, separation does occur near the trailing edge of the bomb. Experience has shown that truncating the end into a flat base and designating it a separated flow region through an appropriate input (see line 702, column 1, Appendix A) yields better results than attempting to model the bomb to exact physical dimensions. The last feature to point out are the wakes, as seen in Figure 2.4. A502i has a limitation in that the wakes must be modelled by the user, and they have the same abutment requirements as physical surfaces. Regardless of angle of attack, the wakes remain stationary with respect to the body to which they are attached. At higher angles of attack, the wakes are no longer close to paralleling the free-stream velocity. Remodelling the wakes is nearly an impossible task. The fin and base wakes would not be too difficult



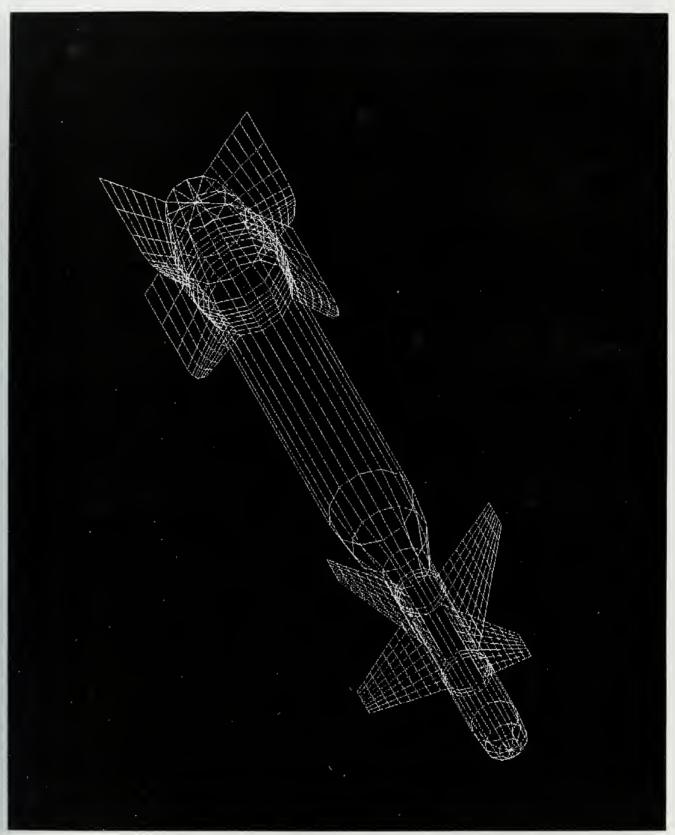


Figure 2.3 GBU-24 Geometry (Wakes not Shown)

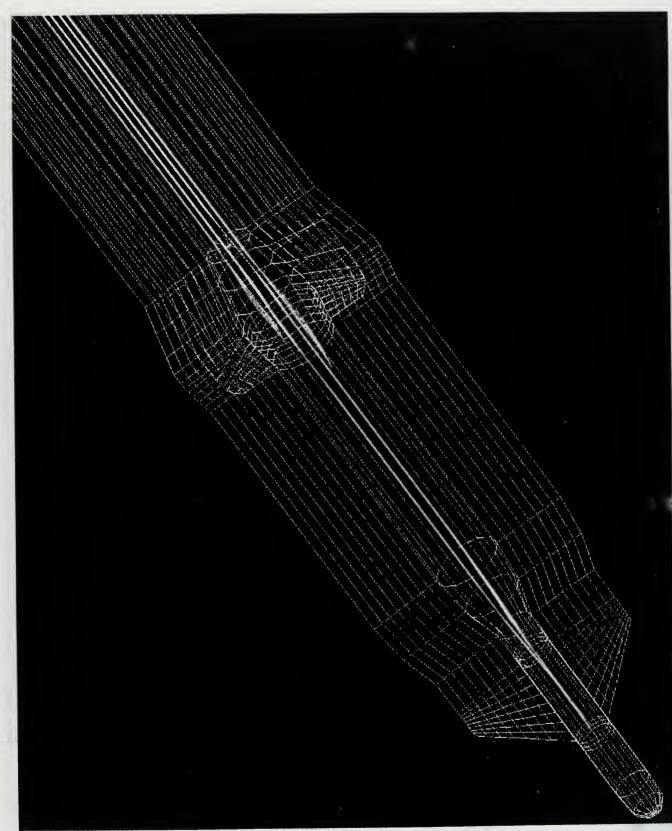


Figure 2.4 GBU-24 Geometry (Wakes Shown)

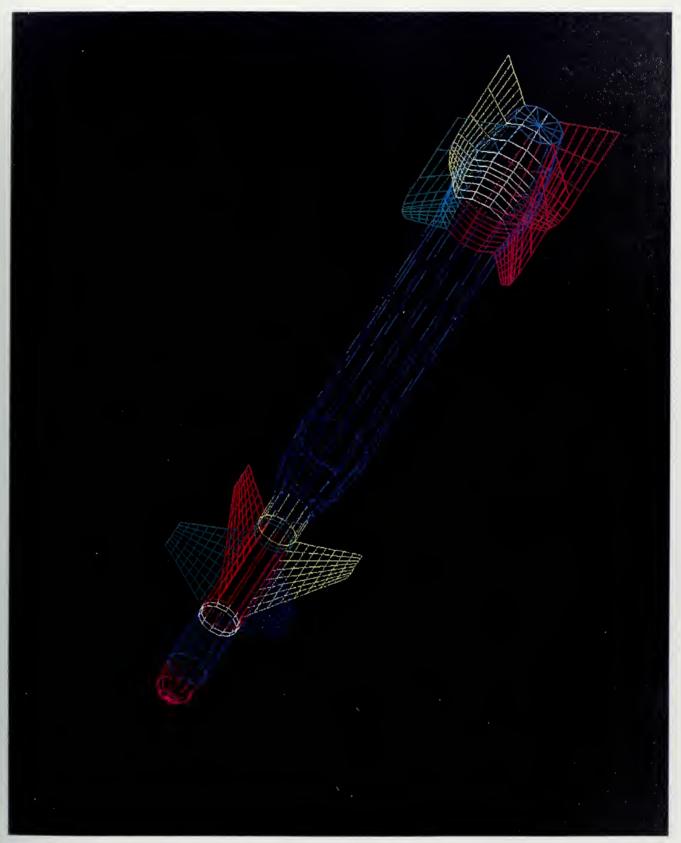


Figure 2.5 GBU-24 Geometry (Network Modelling)



because they do not abut against any physical surfaces except for the surfaces they are trailing from. The canard wakes must abut properly against the bomb's body all the way to the base. Modification of those wakes would entail modification of the entire body, or in a possible simplification, letting the wakes remain attached along the body until the base of the bomb and then shifting them relative to the free-stream.

4. The F-14

The F-14 geometry was modelled in the same fashion as the GBU-24. The geometry consists of approximately 1500 panels. While that may seem fairly coarse for such a complex structure, experience shows that it is all that is required to get accurate predictions. The primary area of interest is the underside of the fuselage forward and between the two nacelles. Higher panel density on the top half is not required. Figures 2.6 and 2.7 display the F-14 geometry without and with wakes shown. Several omissions are made to the model as having a trivial effect on the analysis or no effect at all. Phoenix rails and bomb racks are not modelled along with the chin pod because they are deemed insignificant to achieve reasonably accurate predictions over small angles of attack. External tanks were not considered, but could be modelled much in the same way as the bomb and inserted into the input file to see what effects the drop tanks have on separation forces. The vertical tails and horizontal stabilizers were deemed irrelevant to the prediction of the separation forces and were left out. This reduces the number of panels and networks, which also reduces the amount of time it takes to run a solution.

5. Combination Geometries

The F-14 and GBU-24 were modelled separately, but were combined together as shown in Figure 2.8. The first step to accomplish this was using the FORTRAN code NAVSEP which, among many of its functions will translate coordinates to relocate items in the flow-field. Once accomplished, the GBU-24 file was pasted into the F-14 input file.



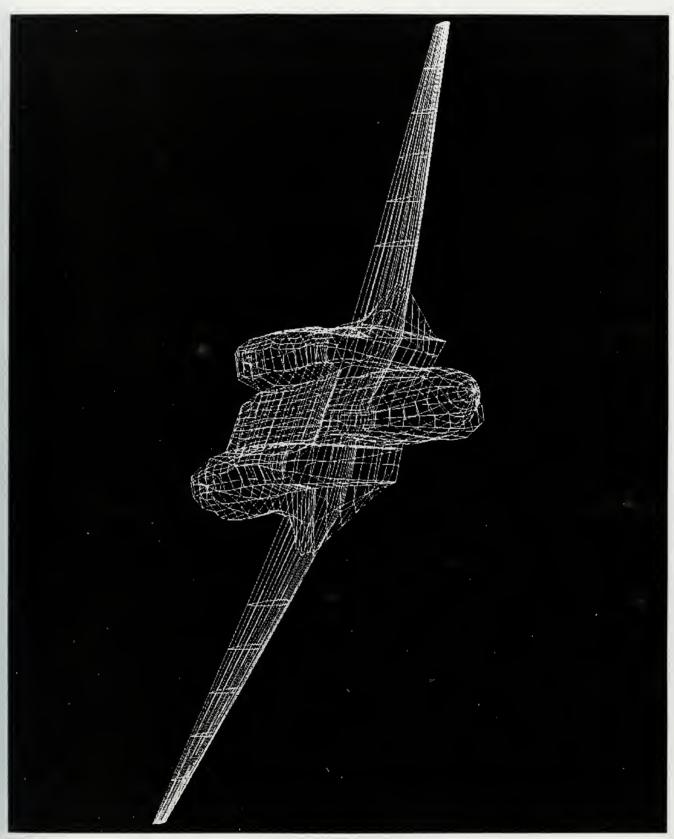


Figure 2.6 F-14 Geometry (Wakes not Shown)

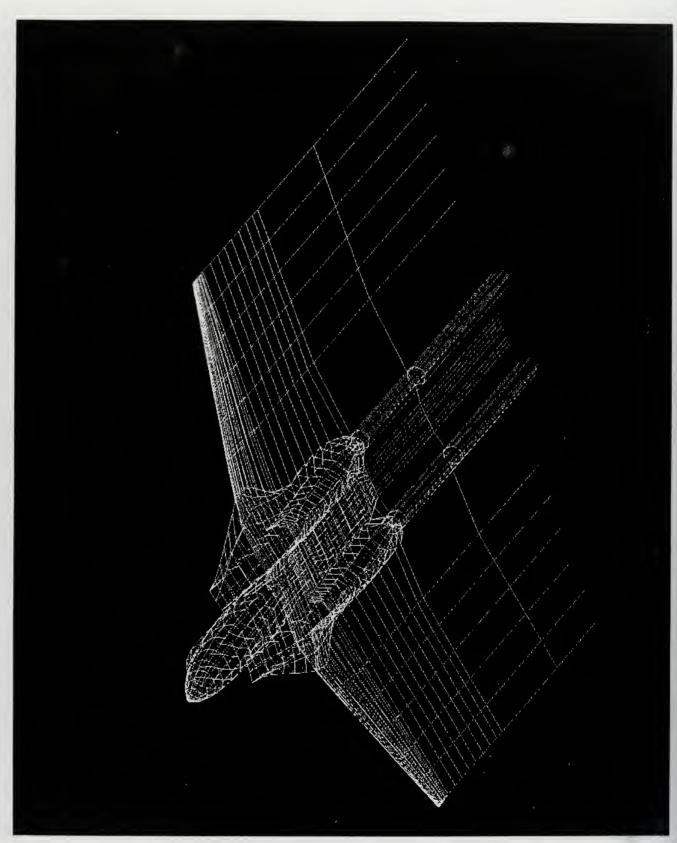


Figure 2.7 F-14 Geometry (Wakes Shown)

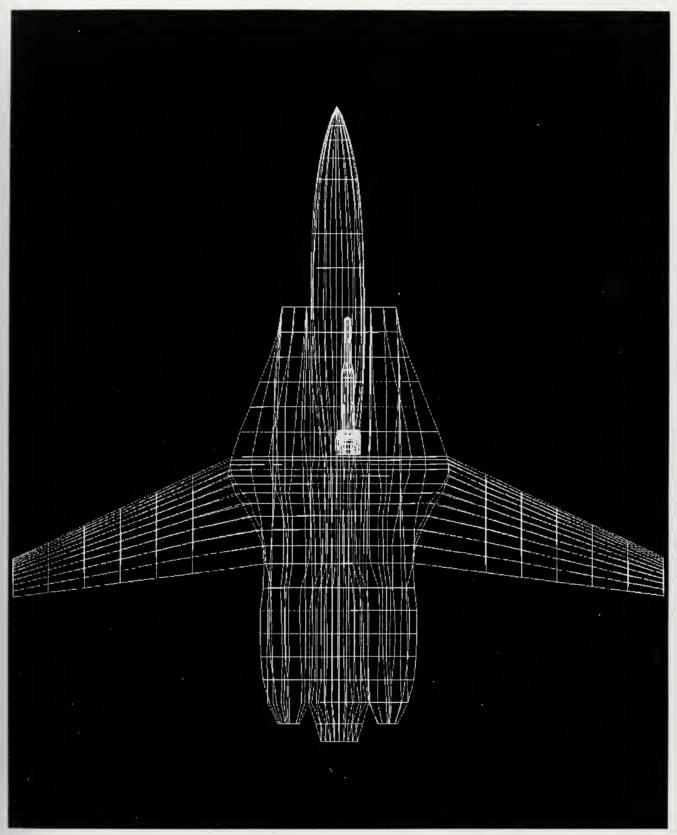


Figure 2.8 F-14 and GBU-24 on Station 3 Combined Geometries

D. GRAPHICS VISUALIZATION

One of the pre/post-processing codes that came with A502i is called RAID. Currently an executable exists in the department's computer system that can be accessed through typing after the UNIX prompt,

raid

Raid is a basic graphics program that can read A502i and TRANAIR input files and display geometries and flow properties from solutions. After accessing raid, it will ask what type of input file it is being asked to visualize. It can handle five other modes of input besides A502i/TRANAIR [Ref. 10]. It will then ask for the name of the input file. A prompt will follow asking about object definition matrices which needs to be answered by,

EACH

The next prompt will ask if the panels are going to be shaded by a Cp value. Cp is used generically in that Cp can be displayed or Mach or any of the relevant 49 surface flow properties [Ref. 4]. This is only used after a solution has been run, data has been extracted and a colorscale for contour plots has been determined. If only the geometry is to be displayed, then hit carriage return for all the next questions until a pink window appears with a menu in the lower left corner of the window. An anomaly of the program is that if you want to display the wakes, then wake display must be deselected. To view the geometry select view on the menu. All selections with the mouse in RAID are made with the center mouse button. A new window appears with a menu bar at the bottom and left and the geometry in the center. From there, rotation, translation, scaling, axes, reflections and other manipulation of the geometry is possible. Figures 2.3 through 2.8 are examples of geometries displayed on RAID.

When presentation of solutions (i.e., Cp or Mach contours) are desired, the use of another post-processing program is required to generate a colormap file. The program is

called crebar. An executable currently exists on the department's system. Type in,

crebar

after the UNIX prompt. The program will ask straightforward questions. Number values associated with colors available can be found in Ref. 10. The color file can be saved under any name, but must lie in the same directory as the input and solution files. The first line of the color file will list four numbers. The first number is the number of colors assigned to the colormap (248 maximum). Occasionally, the color bar displayed in RAID when using a colormap will disappear when certain menu items are selected. To prevent this, change the last three numbers to read 6, 1, -1. Plotting outputs from RAID requires saving the file in a format, such as RGB, that a printer will recognize. It is possible to change the text color and background color, the default is black, to avoid excessive use of black ink in hard copies.

III. DATA EXTRACTION

When a solution has run to completion, there are two files of interest, the arbitrarily named output file and the ft13 file. The arbitrarily named output file contains results for everything that A502i solves for. The ft13 file contains only the 49 surface flow properties on each panel. Appendix D is the solution portion of an arbitrarily named output file for the first network.

For purposes of displaying flow properties on RAID, it is necessary to utilize the ft13 file. A post-processing code called RAIDCONV is used to extract the specific information. To access RAIDCONV, type

raidconv

after the UNIX prompt. An executable currently exists in the department's system. The ft13 file must be in the same directory as RAIDCONV is accessed in. RAIDCONV will prompt the user for which kind of panel method is being used (A502i is one of three choices). The next prompt will ask for the name of the ft13 file. The last prompt will ask for the flow property that is to be extracted. A file called ft13.cp will be created. It can be renamed for purposes of multiple flow properties extraction. Abbreviations for the 49 flow properties can be found at the bottom of page 1 of Appendix D. The two primary flow properties are

LMACHU for local Mach number

CP2ND for second order pressure coefficient

CP2ND is the default setting for RAIDCONV. Once the ft13.cp file is created, RAID can be used as previously discussed to display the flow properties. An anomaly of RAIDCONV is that it does not recognize kt=20 type wakes, used where wakes from a wing abut against a body [Ref. 4]. To assist in extracting all the data, the kt=20 wakes

should be placed at the end of the input file. In general, it is good practice to place all wakes at the end of the input file when using A502i.

The arbitrarily named output file duplicates the data found in the ft13 file and includes moments and forces. A502i will sum up the moments and forces on each network and for all networks so far [App. D]. The moments are computed based on the coordinates entered into the input file [Ref. 4 and App. A].

IV. RESULTS OF A502i COMPUTATIONS

A. PARABOLIC ARC AIRFOIL DISCUSSION

This simple geometry was analyzed primarily to evaluate A502i's capabilities by a comparison to known linear theory. To this end, the geometry discussed in section II-C and shown in Figure 2.1 was run by A502i at a Mach of 0.3 and a Mach of 1.5 at an angle of attack of zero. Two of the 49 flow properties that A502i computes [Ref. 4] for each panel are linear Cp and second order Cp, given by

$$CPLIN = -2u_c \tag{4.1}$$

$$CP2ND = -2u_c - [(1-M_{\infty}^2)u_c^2 + v_c^2 + w_c^2]$$
 (4.2)

Where u_c , v_c and w_c are the compressible components of the perturbation velocity. Figure 4.1 plots the linear theory, A502i linear and second order results for the subsonic case, while Figure 4.2 represents the supersonic solution.

Linear theory for parabolic arc airfoils is outlined in Refs. 2 and 3. The equation representing the subsonic case is given by:

$$Cp(x) = \frac{-8 * \tau_{max}}{\pi * \text{chord} * \sqrt{1 - M_{p}^{2}}} * (1 - (.5 - x) * \ln \left| \frac{1 - x}{x} \right|) \text{ where } 0 < x < 1$$
 (4.3)

Equation 4.3 includes a Prandtl-Glauert compressibility correction. The equation representing the supersonic case is given by:

$$Cp(x) = \frac{2\theta}{\sqrt{M_{\infty}^2 - 1}} \quad \text{where } 0 < x < \text{chord}$$

$$\text{and } \theta = \tau_{\text{max}} * \left(\frac{1}{\text{chord}} - \frac{2x}{\text{chord}^2}\right)$$
(4.4)



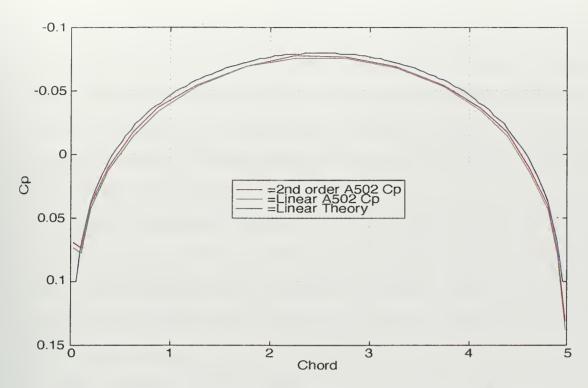


Figure 4.1 Cp Comparison of a Parabolic Arc Airfoil at Mach = 0.3.

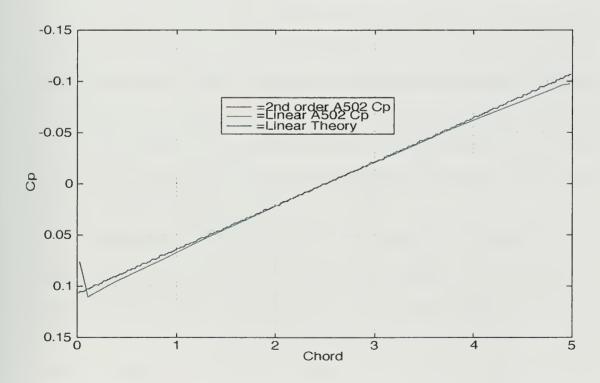


Figure 4.2 Cp Comparison of a Parabolic Arc Airfoil at Mach = 1.5.



Figure 4.1 shows very good agreement with the linear theory curve. There is a small but noticeable difference between A502i's linear results and second order results, with the second order results being more accurate, as expected. The maximum difference between the linear theory curve and the second order A502i curve amounts to a value of 2.5% right at mid-chord. The gap between the two curves from .25 chord to .75 chord were the result of thin panel density in that region.

Figure 4.2 shows excellent agreement with the linear theory curve. The A502i values of Cp for the linear and second order analysis are virtually identical. There are small deviations from linear theory near the leading and trailing edges, but this is expected due to numerical error associated with the discontinuity A502i would encounter right on the leading or trailing edges.

B. DELTAWING DISCUSSION

Reference 9 provides data on Mach distribution, using approximated linear theory, over a deltawing of the configuration discussed in section II-D. This simple geometry provided another test of A502i's capabilities. Figures 4.3 and 4.5 show the A502i results for the subsonic and supersonic case, while Figures 4.4 and 4.6 reflect the results from Ref. 9. For both cases, good agreement is found with the linear theory, with A502i's subsonic analysis being physically more accurate than the approximate linear theory, while A502i's supersonic analysis is not as physically accurate.

A comparison of Figures 4.3 and 4.4 reveals several points of interest. The Mach contour representing the free-stream value is given by the dashed line. All lines outside the dashed line represent areas where the Mach value is less than free-stream, and inside the dashed line is where the Mach value is more than free-stream. The location of where the free-stream Mach contour, in Figure 4.3, intersects the centerline agrees very well with Figure 4.4. However, Figure 4.4 does not have the contour extending all the way to the

tip. This is a physical limitation of the approximate theory used in Figure 4.4 and A 502i is giving a more realistic solution. Figure 4.4 suggests that the peak Mach value occurs at approximately two-thirds chord along the centerline. The A502i results show the peak Mach contour occurring out midway along the semi-span. Those Mach values are less than 1% larger than the yellow Mach contour surrounding it, and can be attributed to how the panel density increases with movement towards the wingtip. A502i performed very well for this subsonic case.

A comparison of Figures 4.5 and 4.6 shows that A502i did not perform as well as in the subsonic case. Again, the contour representing the free-stream value of Mach =1.414 is given by the dashed line. All lines forward are below free-stream and all lines aft are above free-stream. Figure 4.6 shows the intersection of the free-stream Mach contour on the centerline occurring at approximately 39% chord, which is in excellent agreement with A502i's result. Figure 4.6 shows the peak Mach value occurring at the trailing edge on the centerline. This makes more physical sense than the results that A502i yielded. The maximum thickness of the deltawing occurs along the centerline, allowing for greater expansion. The discrepancy may be attributable to panel density and accumulation of numerical error. A close study of the A502i results reveals some discontinuities along the column of panels out at the wing-tip which would have adversely affected the solution and caused errors to propagate along the semi-span.

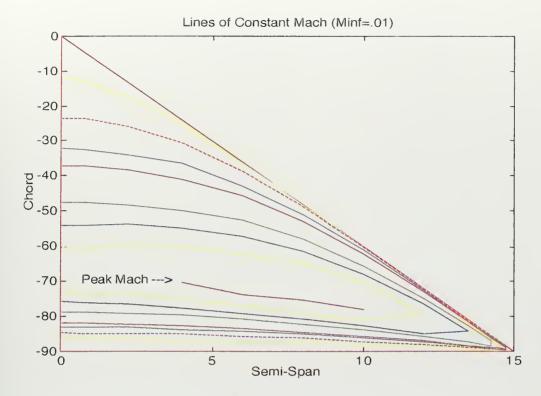


Figure 4.3 A502i Mach Contour Plot (M∞=.01)

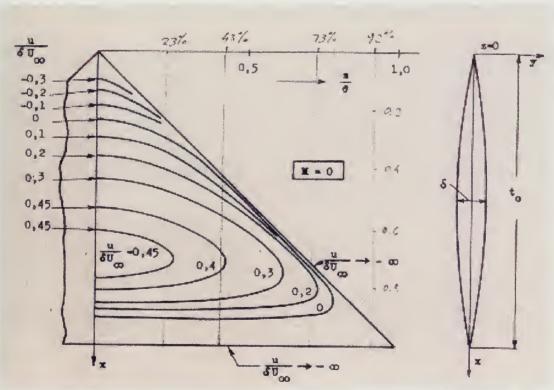


Figure 4.4 Approximate Linear Theory [Ref. 9] M_{∞} =0



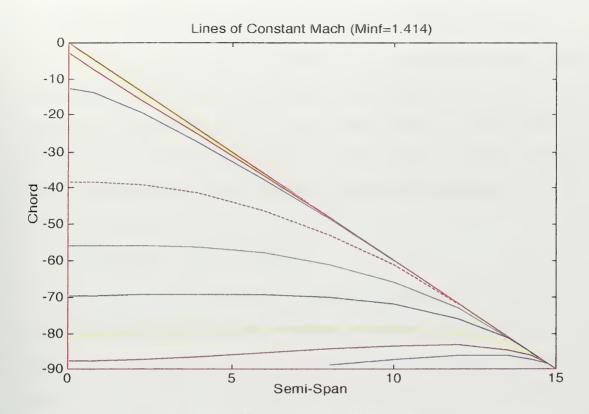


Figure 4.5 A502i Mach Contour Plot $(M_{\infty}=1.414)$

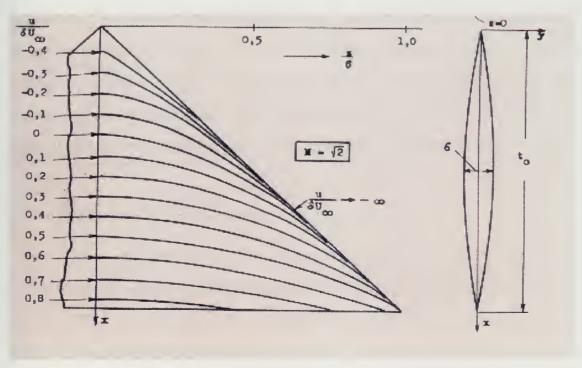


Figure 4.6 Approximate Linear Theory [Ref. 9] M_∞=1.414



C. GBU-24 FREE-STREAM (NO CANARDS) DISCUSSION

A free-stream measurement of separation forces on the GBU-24, without canards, was conducted in a wind tunnel for various Mach numbers from .8 to 1.2 [Ref. 7]. Since A502i uses linear potential theory, the model of the GBU-24, without canards, was evaluated at both Mach .8 and 1.2, avoiding the transonic regime, to ascertain the accuracy of the code with the given geometry. Normal forces and pitching moments for both cases are plotted and compared to the wind tunnel data.

1. Subsonic Case $(M_{\infty}=0.8)$

The GBU-24 model, without the canards, was run for angles of attack varying from -10 to +10 degrees in two degree increments. Values much higher than that ran into wake modelling problems as the wake's angle relative to the free-stream was getting large enough that results would become questionable, and remodelling the wake was too difficult for such a complex geometry. The results of the A502i analysis are displayed in Figures 4.7 and 4.8. For angles of attack between -4 and +4 degrees, A502i does a good job of predicting the separation forces. The pitching moment, which happens to be unstable without the canards, is approximately linear over the -4 to +4 degree range and is the limiting factor to the models accuracy. The normal force is approximately linear over a wider range, and A502i does a good job of predicting the normal forces from -6 to +6 degrees.

2. Supersonic Case $(M_{\infty}=1.2)$

The results for the subsonic case demonstrated that the effective range of angle of attack that A502i needed to explore was from -6 to +6 degrees. Figures 4.9 and 4.10 plot the comparison of wind tunnel data versus A502i results for pitching moment and normal force. The results for the supersonic case are slightly better than that of the subsonic case. The actual pitching moment of the GBU-24 is approximately linear over a wider angle of



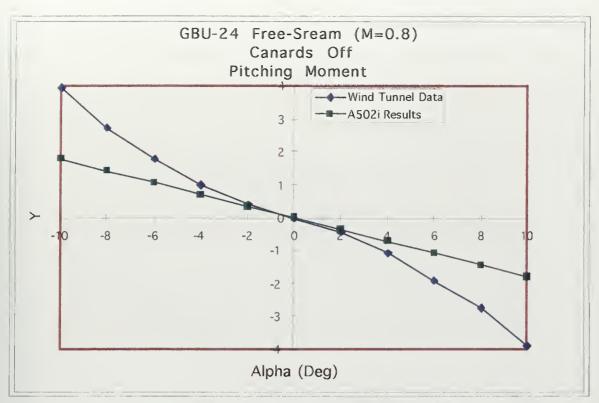


Figure 4.7 Comparison of Pitching Moments



Figure 4.8 Comparison of Normal Forces

attack region, but fluctuations in the data at -6 and +6 degrees means that the model is still only viable from -4 to +4 degrees. The normal force line is nearly linear from -10 to +10 degrees and extrapolating the A502i results out to 10 degrees would still yield good predictions.

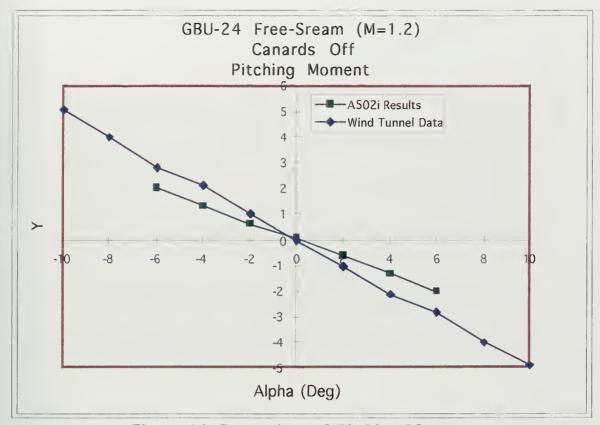


Figure 4.9 Comparison of Pitching Moments



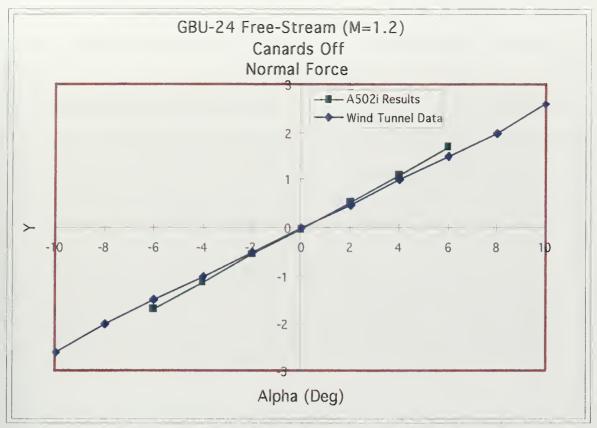


Figure 4.10 Comparison of Normal Forces

D. GBU-24 FREE-STREAM (WITH CANARDS) DISCUSSION

As in the case with no canards, free-stream measurements of the separation forces on GBU-24 were taken from Mach .8 to 1.2 in a wind tunnel [Ref. 7]. Again, due to the limitations of linear theory inherent in the code, an analysis was done for Mach numbers of .8 and 1.2 to minimize transonic effects. Even with the more complex geometry, A502i does an accurate job of predicting the separation forces over the range of angles of attack that are approximately linear.

1. Subsonic Case $(M_{\infty}=0.8)$

The GBU-24 model, with canards, was run in two degree increments of angle of attack from -10 to +10. The wake modelling limitation, as well as reviewing the data from the wind tunnel measurements [Ref. 7] showed the non-linearity of the separation forces at



the higher values of angle of attack, precluded any attempts to predict forces beyond the aforementioned angle of attack interval. The results of the A502i analysis are displayed in Figures 4.11 and 4.12. The addition of the canards makes the pitching moment stable, but linear over a smaller region than without the canards. A502i gave accurate results from -2 to +2 degrees angle of attack when predicting pitching moment. The prediction of normal forces fared better, showing accurate results from -3 to +3 degrees angle of attack.

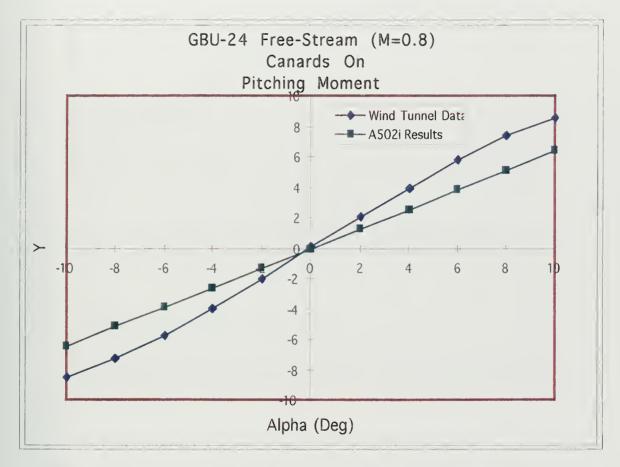


Figure 4.11 Comparison of Pitching Moments



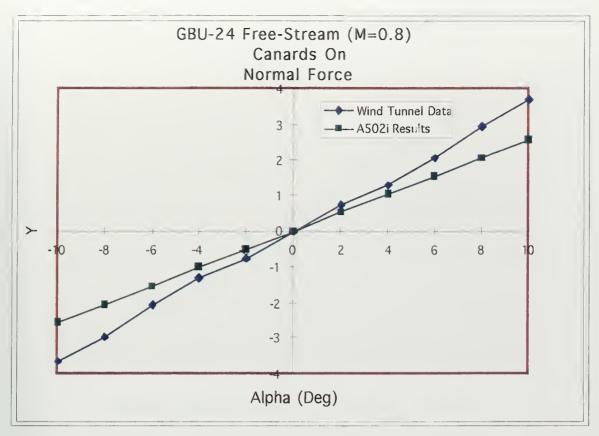


Figure 4.12 Comparison of Normal Forces

2. Supersonic Case $(M_{\infty}=1.2)$

As in the case with no canards, the region of accuracy, with the model used, was assumed to be less than + or - 10 degrees angle of attack. Cases were run from -6 to +6 degrees angle of attack in two degree increments. A comparison of A502i results with wind tunnel data is shown in Figures 4.13 and 4.14. For both the pitching moment and the normal force, A502i does a much better job of prediction then when subsonic. The wind tunnel data is nearly linear in both pitch moment and normal force from -8 to +8 degrees angle of attack. Extrapolating the A502i data out to + or - 8 degrees angle of attack, shows excellent agreement with the wind tunnel data.



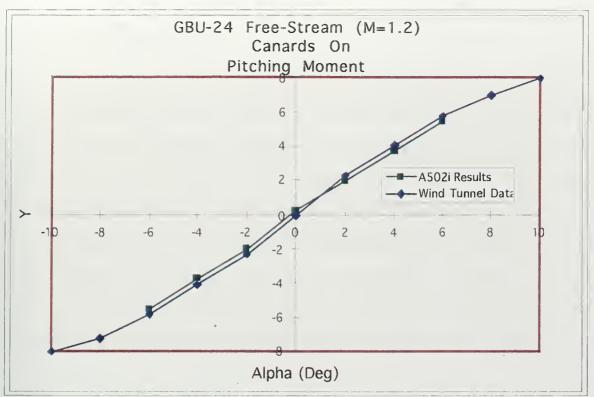


Figure 4.13 Comparison of Pitching Moments

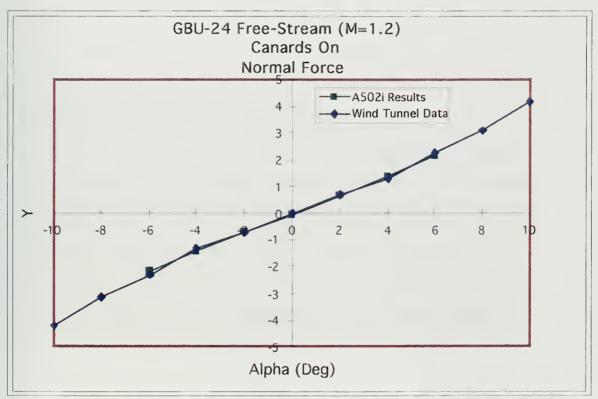


Figure 4.14 Comparison of Normal Forces



E. F-14 DISCUSSION

The GBU-24, without canards was located at station 3 of the F-14 via the NAVSEP code. In the process of running a solution, the combined geometries were found to have a total of 150 networks (A502i's maximum). The combined geometry had about 4,000 panels, far short of the 20,000 panel maximum, so there was room for more detailed modelling, but there was not a chance to insert the GBU-24, with canards, into the F-14's flow field and analyze the forces on the bomb. The geometry with the canardless bomb ran to a solution that appeared to be valid, so there is a high degree of confidence that if the number of networks could be reduced to allow the GBU-24, with canards, to be inserted into the F-14 flow field, the code would yield accurate predictions at small angles of attack on the forward stations. To reduce the total number of networks by combining existing networks would have required a large time investment and the use of MACGS, which the department currently does not possess, the two reasons why it was not done. Figure 4.15 shows a Mach distribution of the solution of the canardless bomb and F-14 at Mach = 0.8 and 0 degrees angle of attack

F. POST-PROCESSING DISCUSSION

The Mach values for the subsonic case of the GBU-24, with canards, at 4 degrees angle of attack, were extracted from the ft13 file. These values, used in conjunction with RAID are shown in Figures 4.16 and 4.17. The color distribution over the nose in Figure 4.16 indicates that the bomb is at an angle of attack, and scanning the rest of the model showed no discontinuous solutions, which is generally represented in A502i by a Mach value of 0 or 1,000. The visual representation is a quick way of telling if A502i ran an accurate solution. The only other way is to individually check the Mach or Cp values of each panel in the ft13 file or the arbitrarily named output file. The other point of interest in Figure 4.16 is the lack of panel density along the mid-section of the bomb. The goal, in the



case of stores separation prediction, is to have as simple a model as possible that still gives accurate predictions. The fewer the number of panels, the shorter the run time. The fact that A502i is a higher order panel method allows the luxury of using fewer panels. Figure 4.17 highlights the approach used to take into account separation effects as discussed on page 16.



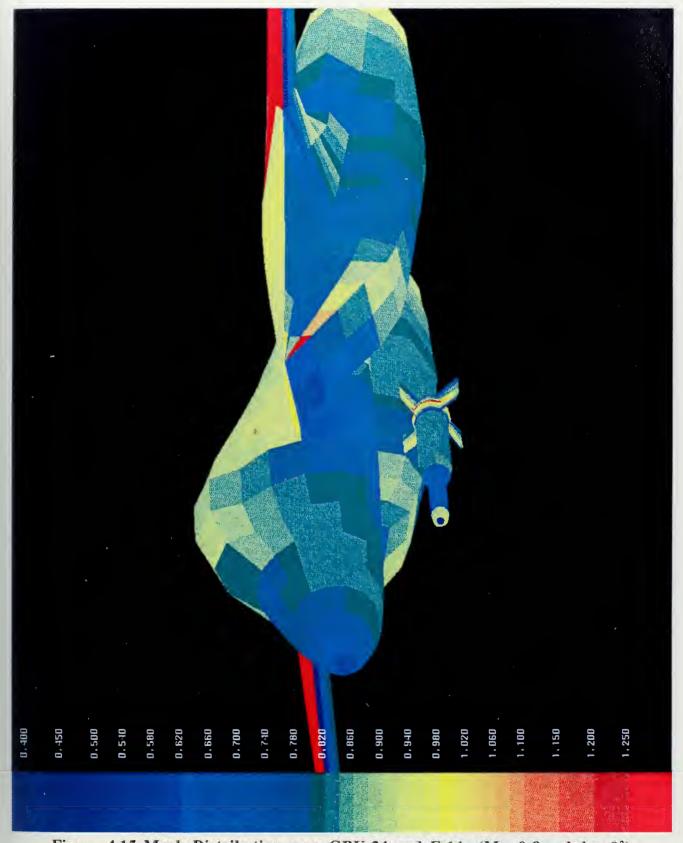


Figure 4.15 Mach Distribution over GBU-24 and F-14 $(M_{\infty}=0.8, alpha=0^{\circ})$





Figure 4.16 Mach Distribution over GBU-24 $(M_{\infty}=0.8, alpha=4^{\circ})$





Figure 4.17 Mach Distribution over GBU-24 (M∞=0.8, alpha=4°)



V. SUMMARY AND CONCLUSIONS

The main goal of this analysis is to determine the accuracy of A502i on both simple geometries and complex geometries. To accomplish this, A502i is compared with results available from linear theory and wind tunnel experiments. This allows conclusions to be drawn on the capabilities as well as the limitations of A502i.

In general, A502i can accurately predict flow properties, forces and moments on simple and complex geometries at low angles of attack. The predictions are valid over a wide Mach range, from 0 up to and including 0.8 and from 1.2 and above. The supersonic solutions are available due to A502i's higher order capabilities.

The limitations of A502i are consistent with most panel methods. A502i cannot predict flow dominated by viscous, separated or transonic effects. It cannot predict flow with different total pressures, such as flow properties inside a jet plume or a propeller slipstream swirl. The biggest shortcoming of A502i is its inability to handle unsteady cases and automatically determine wake shapes.

Experience or knowledge of the flow properties around the geometry being tested is important in building an accurate model. An accurate model may not be physically accurate. Flight test results revealed a yawing moment on the GBU-24 that was not discovered in wind tunnel experiments when the bomb was carried on an aft station. The yawing moment may be caused by the fact that the canards are not fixed, but spring-damped. A502i predictions would not be accurate without inputting a moment to simulate the deflection of the canards, since the canards are fixed by the geometry. A502i, while a powerful tool in terms of cost savings and time, cannot completely substitute for wind tunnel experiments and flight tests, as constructing a complex geometry to exact physical specifications will probably not yield accurate predictions.

APPENDIX A. GBU-24 OUPUT FILE (INPUT FILE PORTION)

	***************************************		# # # # # # # # # # # # # # # # # # #	
dynamic memory management initialization	ion			
max no. levels 15 max no. arrays addr(maplev) 0 addr(maplws)		200 maximum scratch storage 0 addr(scratch storage)	900000 total sto	total storage provided 900000
wopen call on unit 1 blocks: 10 wopen call on unit 2 blocks: 10 wopen call on unit 3 blocks: 10	**************************************	# # # # # # # # # # # # # # # # # # #	* * * * * * * * * * * * * * * * * * *	

a502 - pan-air ted	pan-air technology program	* * ·		
potential flow about arbitrary configuration version id = ht2 (12 feb 92) boaing ver 100	bitrary configu b 92) boeing ve	configurations .		
07-1	07-Mar-9	* * *		
GBU-24 FREESTREAM M=0.8 \$SOLUTION				
* * **********************************	***************************************	* * * * * * * * * * * * * * * * * * * *		
- list of a502 input data cards	nput data cards			
1 \$TITLE 2 GBU-24 FREESTREAM M=0.8 3 \$SOLUTION				
6 0. 7 \$MACH NUMBER 8 =AMACH				
12 1. 13 \$ANGLES-OF-ATTACK 14 =ALPC				
2.				

Page 3																																						
resunts	-12.374 -12.374	-3.138	-3.138	-3.138		-4.642	-4.642	-4.642	-6.146	-6.146	-6.146			-7.650	•	-	9.1	-9.154	۲.۲	9.	9.	-10.658		12.163	-12.162	12.161	13 657	13.667	-13.666	.13.665	Ľ	-15.171	ഗ	ഗ				,
	15.170	-2.324	-2.324	-2.324			-3.581	•	•	-4.839			-6.099	-6.095	-6.093	~	. m	-7.352	η.	.615	.612	-8.608)	.873	19.869	.861	131	.127	-11.122 -	.117	389	-12.384 -	.379	.374				, 00
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	-12.381 -12.376 -12.371 2CAN3	m m	-3.138	. n	<u>س</u> ۲	 • •	-4.642	-4.642	-6.146	-6.146	-6.146	-6.145	-7.650	-7.650	-7.650	-7.649	-9.154	-9.154	-9.153	-10.659	-10.659	-10.658	-10.657	-12.163	-12.162	-12.161	-12.161	-13.667	-13.666	-13.665	-13.665	-15.171	-15.170	-15.169	CAN1			000
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-3.300	-4.000	-3.463	-2.165	0.000	2.007	3.301	4.000	3.463	2.159	0.000	-1.995	-3.300			-3.999 -1.995	2.007 -2.007	3.999	1 995	-1.995	-2.007	2.007	1.995			0.000	0.000	0.000	0.000	-3.086	0.000	
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APPENDIX B. GBU-24 OUPUT FILE (EDGE ANALYSIS)

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12.4 13.3 Dabutment #	u u				3 2 3	
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Ŀ	2	12 4 12 4			3 4 5 6 7 8 9 10 11 12 13 13 12 11 10 9 8 7 6 5 4 3	
		dblt edge			#	
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Oabutment #	35	dblt edge			starts at ai # 23 ends at ai # 24	
					edge points (minus (-) indicates po	int moved by Seat

Page 66 28 indicates point moved by \$eat 10 11 2 1 2 1 ends at ai # 25
points (minus (-) indicates point moved by \$eat 5 -6 -7 8 9 -10 11 7 -6 -5 4 3 -2 1 5 -6 -7 8 9 -10 11 starts at al # 27 ends at al # 26 corresponding edge points (minus (-) indicates point moved by \$eat 4 5 6 7 4 3 2 1 \$eat starts at al # 25 ends at al # 28 corresponding edge points (minus (-) indicates point moved by \$eat 10 -11 12 13 4 -3 2 1 starts at ai # 22 ends at ai # 23 corresponding edge points (minus (-) indicates point moved by \$eat Seat starts at ai # 29 ends at ai # 30 corresponding edge points (minus (-) indicates point moved by \$eat Seat point moved by \$eat starts at ai # 26 ends at ai # 25 corresponding edge points (minus (-) indicates point moved by starts at ai # 28 ends at ai # 27 corresponding edge points (minus (-) indicates point moved by 7 -8 9 10 4 -3 2 1 starts at al # 24 ends at al # 25 corresponding edge points (minus (-) indicates point moved by 1 2 3 4 4 3 2 1 27 indicates F 10 11 2 1 2 1 <u>-</u> ends at ai # boints (minus (5 6 7 8 7 6 5 4 7 6 5 4 ends at ai minus points 5 6 7 6 starts at a1 # 29 corresponding edge p 1 2 3 4 5 11 10 9 8 7 corresponding edge p
1 2 3 4 5
11 10 9 8 7
1 2 3 4 5 corresponding e 1 2 3 11 10 9 11 10 9 ai # ai # 1 -2 4 -3 10 -11 starts at starts at 13 12 kutta-fl matching mu-match matching mu-match matching matching matching matching matching matching matching mu-match matching mu-match mu-match mu-match mu-match mu-match mu-match mu-match mu-match type type 12 4 12 4 edge type 4 type 4 edge type edge type 4 edge type edge 4 N dblt type 12 12 type 12 12 dblt type 12 12 dblt tуре 12 12 dblt type 12 12 dblt type 12 12 12 dblt type 12 12 12 db1t type 12 12 12 dblt dblt type 12 12 12 12 nw/id nw/id nw/id nw/id nw.edge nw/id 13.2 13.4 Oabutment # 37 nw/id nw.edge nw/id 14.1 17.4 Oabutment # 39 nw/id nw/1d nw/id 15.1 16.3 19.4 Oabutment # 43 nw/id 23.4 32.1 Oabutment # 44. nw/id 36 21.4 Oabutment # 38 Oabutment # 40 15.4 Oabutment # 41 Oabutment # 45 46 Oabutment # 42 Mar 7 1996 13:5 Oabutment # nw.edge 15.2 nw.edge 15.3 14.3 Oabutment nw.edge nw.edge nw.edge nw.edge nw.edge nw.edge

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<pre># 38 (-) indicates point moved by \$eat 9 10 11</pre>	starts at ai # 37 ends at ai corresponding edge points (minus (1 2 3 4 5 6 7 8	kutta-fl	matching mu-match	dblt edge type type 12 4	nw/id	nw.edge 20.2
# 37 -) indicates point moved by \$eat *** warning	starts at ai # 27 ends at ai # corresponding edge points (minus (-) 1 2 3 4 5 6 7 ro along this abutment	y kutta-fl natched to zero	matching kutt mu-match strength matched	dblt edge type type 12 4 doublet	nw/id # 56	nw.edge 20.1 0abutment
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<pre># 35 (-) indicates point moved by \$eat *** warning # 36 (-) indicates point moved by \$eat 9 10 11</pre>	starts at ai # 28 ends at ai corresponding edge points (minus 1 2 3 4 5 6 7 along this abutment ends at ai starts at ai # 35 ends at ai corresponding edge points (minus corresponding edge points edge points edge edge edge edge edge edge edge edg	kutta-fl natched to zero	matching kutt mu-match strength matched matching kutt	dblt edge type type 12 4 doublet: dblt edge type type 12 4	nw/id # 53 nw/id	nw.edge 19.1 0abutment nw.edge
34 -) indicates point moved by \$eat *** warning	starts at ai # 32 ends at ai # corresponding edge points (minus (-) 1 2 3 4 5 6 7 7 6 5 4 3 2 1 ro along this abutment	matching kutta-fl vor-mtch mu-match vor-mtch trength matched to zero	to .	dblt edge type type 12 4 18 5 doublet	# 51 nw/id # 52	nw.edge 18.3 24.1 0abutment
<pre># 34 (-) indicates point moved by \$eat 9 10 11</pre>	starts at ai # 33 ends at ai # corresponding edge points (minus (- 1 2 3 4 5 6 7 8 9	kutta-fl	matching mu-match	dblt edge type type 12 4	n	
33 -) indicates point moved by \$eat *** warning	starts at ai # 26 ends at ai # corresponding edge points (minus (-) 1 2 3 4 5 6 7 ro along this abutment	kutta-fl	e matching kutt mu-match strength matched	dblt edge type type 12 4 doublet	nw/id # 50	nw.edge 18.1 Oabutment
31) indicates point moved by \$eat *** warning	starts at ai # 32 ends at ai # corresponding edge points (minus (-) 1 2 3 4 10 9 8 7 7 4 5 6 7 ro along this abutment	kutta-fl	mu-match strength matched	dblt edge type type 12 4 12 4 18 5 doublet	n K	nw.edge 17.2 23.4 32.1 0abutment
26) indicates point moved by \$eat 10 11 2 1 2 1 2 1	starts at a1 # 32 ends at a1 # corresponding edge points (minus (-) 1 -2 3 4 -5 -6 7 8 9 11 -10 9 8 -7 -6 5 4 3 11 -10 9 8 -7 -6 5 4 3	kutta-fl	matching mu-match	dblt edge type type 12 4 12 4 12 4	nw/id	nw.edge 17.1 18.4 21.3
) indicates point moved by \$eat	corresponding edge points (minus (-) 1 2 3 4 7 6 5 4 7 8 9 10	kutta-fl	matching mu-match	type type 12 4 12 4 18 5	nw/id	nw.edge 16.2 23.4 32.1

Mar 7 1996 13:51				results	Page 68
Oabutment # 57 nw.edge nw/id 20.3 27.1 Oabutment # 58 nw.edge nw/id 21.2 23.4 32.1 Oabutment # 59	dblt edge type type 12 4 18 5 dblt edge type type 12 4 12 4 18 5 doublet s	matching kutte vor-mtch mu-match vor-m matching kutte mu-match	1-f1 tch 1-f1	starts at a1 # 31 ends at a1 # 38 corresponding edge points (minus (-) indicates point moved by \$eat	at hat warning **
nw.edge nw/id 22.1 0abutment # 60	dblt edge type type 12 4 doublet s	matching Kutta-fl mu-match strength matched to	kutta-fl cched to zer	starts at ai # 25 ends at ai # 39 corresponding edge points (minus (-) indicates point moved by \$eat 1 2 3 4 5 6 7 zero along this abutment *** wan	aat warning **
y # 3"	dblt edge type 12 4 dblt edge type type type 12 4 l8 5	matching mu-match matching vor-mtch	kutta-fl kutta-fl vor-mtch	starts at al # 39 ends at al # 40 corresponding edge points (minus (-) indicates point moved by \$eat 1 2 3 4 5 6 7 8 9 10 11 starts at al # 30 ends at al # 40 corresponding edge points (minus (-) indicates point moved by \$eat 7 6 5 4 3 2 1	
nw.edge nw/id 23.1 23.3 0abutment # 63	dblt edge type type 12 4 12 4 wake side	blt edge ype type matching kutta-fl 12 4 mu-match 12 4 wake side edge left unabutted	kutta-fl unabutted	starts at ai # 41 ends at ai # 30 corresponding edge points (minus (-) indicates point moved by \$eat 1 2 1 1 2 1 *** was	eat warning **
nw.edge nw/id 24.2 Oabutment # 64	dblt edge type type 18 2 wake trai	blt edge ype type matching kutta-fl 18 2 wake trailing edge unabutted	kutta-fl Inabutted.	<pre>starts at ai # 34 ends at ai # 42 corresponding edge points (minus (-) indicates point moved by \$eat</pre>	inder **
nw.edge nw/id 24.3 Oabutment # 65	dblt edge type type 18 2 wake side	blt edge ype type matching kutta-fl 18 2 wake side edge left unabutted	kutta-fl unabutted	<pre>starts at ai # 42 ends at ai # 43 corresponding edge points (minus (-) indicates point moved by \$eat 1 2 3 4 5 6 7 was</pre>	sat warning **
nw.edge nw/id 24.4 0abutment # 66	dblt edge type type 18 2 wake side	blt edge ype type matching kutta-fl 18 2 wake side edge left unabutted	kutta-fl unabutted	<pre>starts at ai # 43 ends at ai # 32 corresponding edge points (minus (-) indicates point moved by \$eat 1 2</pre>	ning **
nw.edge nw/id 25.2 Oabutment # 67	dblt edge type type 18 2 wake trai	ublt edge .ype type matching kutta-fl 18 2 wake trailing edge unabutted	kutta-fl ınabutted.	<pre>starts at ai # 40 ends at ai # 44 corresponding edge points (minus (-) indicates point moved by \$eat 1 2 wake filaments will be added *** gentle reminder **</pre>	inder **
nw.edge nw/1d 25.3 Oabutment # 68	dblt edge type type 18 2	matching kutta-fl	kutta-fl	starts at ai # 44 ends at ai # 45 corresponding edge points (minus (-) indicates point moved by \$eat 1 2 3 4 5 6 7	

	points (minus (-) indicates point m 5 6 7 8 9 10 11 12 13 1 8 6 be added	starts at a1 # 51 ends at a1 # 13 corresponding edge points (minus (-) indicates point m 1 2 3 4 5 6 7 8 9 10 11 12 13 1	starts at ai # 50 ends at ai # 51 corresponding edge points (minus (-) indicates point m 1 2 3 4 5 6 7 8 9	starts at ai # 14 ends at ai # 50 corresponding edge points (minus (-) indicates point m i 2 3 4 5 6 7 8 9 10 11 12 13 1 wake filaments will be added *	starts at ai # 49 ends at ai # 31 corresponding edge points (minus (-) indicates point m 1 2	starts at ai # 48 ends at ai # 49 corresponding edge points (minus (-) indicates point m 1 2 3 4 5 6 7	starts at ai # 38 ends at ai # 48 corresponding edge points (minus (-) indicates point m 1 2 ake filaments will be added *	starts at ai # 47 ends at ai # 29 corresponding edge points (minus (-) indicates point m 1 2	starts at ai # 46 ends at ai # 47 corresponding edge points (minus (-) indicates point mo 1 2 3 4 5 6 7	starts at ai # 36 ends at ai # 46 corresponding edge points (minus (-) indicates point mo 1 2 wake filaments will be added *	
69 and the tentiment	52 indicates po 10 11 12	13 indicates point moved by \$eat 10 11 12 13 14 15 16 *** warning	51 indicates point moved by \$eat *** warning **	50 indicates point moved by \$eat 10	31 indicates point moved by \$eat *** warning **	49 indicates point moved by \$eat *** warning **	48 indicates point moved by \$eat *** gentle reminder **	29 indicates point moved by \$eat *** warning **	47 indicates point moved by Seat *** warning **	indicates point moved by \$eat *** gentle reminder **	*** warning **

starts at ai # 53 ends at ai # 5 corresponding edge points (minus (-) indicates point moved by \$eat 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 **** wa
starts at ai # 2 ends at ai # corresponding edge points (minus (-) 4 5 6 7 8 9 wake filaments will be added
starts at a1 # 54 ends at a1 # 55 corresponding edge points (minus (-) indicates point moved by \$eat 1 2 3 4 5 6 7 8 9 *********************************
starts at ai # 55 ends at ai # 1 corresponding edge points (minus (-) indicates point moved by \$eat 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 *** wa
starts at al # 10 ends at al # corresponding edge points (minus (-) 1 2 3 4 5 6 7 8 9 9 wake filaments will be added
starts at al # 56 ends at al # 57 corresponding edge points (minus (-) indicates point moved by \$eat 1 2 3 4 5 6 7 8 9 *********************************
starts at a! # 57 ends at a! # 9 corresponding edge points (minus (-) indicates point moved by \$eat
starts at ai # 45 ends at ai # 45 corresponding edge points (minus (-) indicates point moved by \$eat 1 2 3 4 5 6 7 8 9 10 11 12 13
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APPENDIX C. GBU-24 OUTPUT FILE (UNIT NORMALS)

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t/abtidn abtcal/anl *e*libgeoa control p	t/abtidn abtcal/anl 0*e*libgeoab 0 control points jc jc/naive	t/abtidn 2.099325 abccal/anl 0.000034 0*e*libgeoab 0 control points for network jc jc/naive	rk: 1 zc			znc		nw I	nw panel.sp	jzc ifn jfn izdc abut	n jfn	izdc		ßesj
н	1	45.090395	3.246673	-2.414971	0.00000.0	0.641888	0.766799	П	1.1	H	1 1	н	1	-
2	2	43.834818	3.232000	-2.402644	0.000149	0.641734	0.766927	1	1.8	7	2 1	4	4	4
٣	ъ	41.158462	3.232000	-2.402625	0.00000.0	0.641588	0.767049	1	2.8	m	4 1	4	4	4
4	4	38.481511	3.232000	-2.402625	0.000000	0.641588	0.767049	П	3.8	4	6 1	4	4	4
2	S	35.804544	3.232000	-2.402580	0.000149	0.641392	0.767213	П	8.8	5	8 1	4	4	4
9	9	33.127182	3.232000	-2.402562	0.000000	0.641288	0.767301	Н	8.2	6 10	0	4	4	4
7	7	30.449590	3.232000	-2.402562	0.00000.0	0.641288	0.767301	1	8.9	7 12	1	4	4	4
œ	ω	27.771476	3.232000	-2.402515	0.000149	0.641050	0.767499	Н	7.8	8 14	- 1	4	4	4
6	6	25.093237	3.230462	-2.401216	0.000000	0.640987	0.767552	Н	8.8	9 16	1	4	4	4
10	10	24.013415	3.231929	-2.402441	0.00000.0	0.640987	0.767552	1	8.4	10 17	, 1	2	ю	٣
11	11	45.085496	3.858495	-2.927114	0.000149	0.641734	0.766927	1	1.5	11	1 2	7	0	-
12	12	43.930127	3.885736	-2.949683	0.000149	0.641734	0.766927	1	1.5	12	2 2	0	0	0
13	13	41.359743	3.885756	-2.949450	0.00000.0	0.641588	0.767049	1	2.5	13	4 2	0	0	0
14	14	38.789418	3.885803	-2.949489	0.000000	0.641588	0.767049	+	3.5	14	6 2	0	0	0
15	15	36.219655	3.885870	-2.949298	0.000149	0.641392	0.767213	-	4.5	15	α	c	c	0

APPENDIX D. GBU-24 OUTPUT FILE (SOLUTION DATA)

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panel/source	140654 68550 35875 35875 32254 25193 1890	1/00	tics s: 0	* * * *	: * * * *	simultaneous	ctack = 2.00000 compressibility angle	0.03490)	type = 0	0p	pheu	phel	vtu	0.4701	-0.6205
		sient generation 0 ncalt= 112589	solver statistics 100 status:	.*************************************	0.257794E-12		Ø	0.00000	1 source	7	wzn	wzl	pwnl	-2.9497	-0.0662
	diate field diate field field	ence coefficient J= 16313 1	flag for blocks:	************	solution 0		angle of 0.60000	0.99939,	index:	>-	m&m	wyl	numd	3.8857	0.0789
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mai / 1980 1950 Dic counts	no influence monopole far field dipole far field quadrupole far field one sub-panel interm two sub-panel interm eight sub-panel near	ncalg= n56chg: 1.	Ological flags for cp F = bkprnt, p wopen call on unit			1 0*b*solution	mach number = 0.8000 compressibility factor	freestream velocity =	network id:	jc ip	lmachu	lmachl snl	nun pus	12 1	0.7580

0.7545 0	0.8131	18 7 28	0.0000	0.7654	0.8008	17 6 31 0234	0.0000	0.7739	0.7916	16 5 33	0.0000	0.7814	7824	15 4 36	0.0000	0.7878	0.7731	14 3 38	0.0000	0.7932	0.7630	13 2 41 0234	0.0000	.0990 0.7889 0.7889	Mar 7 1996 13:51
0.9818	1.0051	28.5100	0.0000	0.9863	1.0003	31.0801	0.0000	0.9898	0.9967	33.6500	0.0000	0.9927	0.9932	36.2197	0.0000	0.9949	0.9896	38.7894	0.0000	0.9960	0.9851	41.3597	0.0000	0.9920	
0.0082	-0.0197	3.8862	-0.0268	0.0085	-0.0168	3.8861	-0.0268	0.0051	-0.0114	3.8860	-0.0269	-0.0048	-0.0004	3.8859	-0.0268	-0.0216	0.0174	3.8858	-0.0268	-0.0465	0.0430	3.8858	-0.0269	-0.0815	
-0.0070	0.0162	-2.9490	-0.0268	-0.0071	0.0140	-2.9492	-0.0268	-0.0043	0.0095	-2.9491	-0.0269	0.0038	0.0002	-2.9493	-0.0268	0.0181	-0.0145	-2.9495	-0.0268	0.0389	-0.0360	-2.9495	-0.0269	0.0680	
-0.7263	-0.3060	0.4202	1.0007	-0.8401	-0.2883	0.5518	0.9906	-0.9271	-0.2984	0.6287	0.9801	-0.9903	-0.3345	0.6558	0.9694	-1.0330	-0.3976	0.6353	0.9571	-1.0617	-0.4911	0.5707	0.9500	-1.0905	
0.9479	1.0140	0.0661	0.9606	0.9606	1.0005	0.0400	0.9704	0.9704	0.9905	0.0201	0.9790	0.9790	0.9801	0.0012	0.9863	0.9859	0.9691	-0.0168	0.9921	0.9903	0.9554	-0.0349	0.9866	0.9809	results
0.0082	-0.0197	-0.0279	0.0012	0.0085	-0.0168	-0.0253	0.0118	0.0051	-0.0114	-0.0166	0.0294	-0.0048	-0.0004	0.0043	0.0546	-0.0216	0.0174	0.0389	0.0905	-0.0465	0.0430	0.0896	0.1377	-0.0815	
-0.0082	0.0166	0.0248	0.0516	-0.0080	0.0140	0.0220	0.0414	-0.0050	0.0093	0.0143	0.0263	0.0033	-0.0003	-0.0036	0.0146	0.0177	-0.0152	-0.0330	0.0392	0.0387	-0.0370	-0.0757	0.0856	0.0676	
0.1060	-0.0280	0.0000	-0.0814	0.0806	-0.0008	0.0000	-0.0411	0.0608	0.0196	0.0000	-0.0021	0.0431	0.0410	0.0000	0.0359	0.0281	0.0641	0.0000	0.0750	0.0179	0.0930	0.0000	0.0825	0.0348	
0.1042	-0.0287	0.0000	-0.0803	0.0788	-0.0015	0.0000	-0.0404	0.0592	0.0189	0.0000	-0.0023	0.0421	0.0398	0.0000	0.0340	0.0274	0.0614	0.0000	0.0704	0.0157	0.0862	0.0000	0.0739	0.0270	
0.1032	-0.0288	0.0196	-0.0797	0.0782	-0.0015	0.0196	-0.0401	0.0589	0.0188	0.0196	-0.0023	0.0419	0.0397	0.0196	0.0337	0.0273	0.0610	0.0196	0.0697	0.0157	0.0854	0.0196	0.0728	0.0269	Page 1
0	-0	0	-0	0	-0	0	-0	0	0	0	-0	0	0	0	0	0	0	0	0	0	0	0	0	0	Page 145

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0.0000	0.0000	-0.0269	-0.0269	1.0143	0.9479	0.0150	0.0617	-0.1339	-0.1329	-0.1320	0-
19 8	25.9399	3.8863	-2.9489	0.2091	0.1259	-0.0564	0.0500	0.000	0.0000	0.0195	0
0.8428	1.0159	-0.0363	0.0303	-0.3655	1.0449	-0.0363	0.0313	-0,0908	-0.0921	-0.0929	0-
0.7307	0.9716	0.0201	-0.0168	-0.5745	0.9190	0.0201	~0.0186	0.1644	0.1614	0.1589	0
0.0000	0.0000	-0.0268	-0.0268	1.0460	0.9194	0.0522	0.0945	-0.2551	-0.2535	-0.2518	0-
22 9	43.9956	5.3899	-4.2081	0.6121	-0.0103	0.0309	-0.0261	0.0000	0.0000	0.0178	0
0.7641	0.9858	0.0114	6600.0-	-0.5134	0.9589	0.0114	-0.0109	0.0841	0.0820	0.0813	0
0.7731	0.9890	-0.0195	0.0159	-1.1255	0.9693	-0.0195	0.0152	0.0616	0.0609	0.0605	0
0.0000	0.0000	-0.0271	-0.0271	0.9591	9696.0	0.0555	0.0302	0.0225	0.0211	0.0208	0
23 10	41.6628	5.3899	-4.2076	0.6418	-0.0113	0.0155	-0.0132	0.0000	0.0000	0.0178	0
0.7708	0.9885	0.0025	-0.0021	-0.4271	0.9668	0.0025	-0.0028	0.0678	0.0664	0.0660	0
0.7807	0.9923	-0.0130	0.0109	-1.0689	0.9781	-0.0130	0.0104	0.0442	0.0435	0.0433	0
0.0000	0.0000	-0.0268	-0.0268	0.9668	0.9783	0.0418	0.0220	0.0236	0.0230	0.0227	0
1 network id:	d:	index:	1 source	a type = 0	doublet	type = 12	number	rows = 8	number	columns =	80
jc ip	×	٨	2	90	ğ	фу	zp	0 81	anx	any	প
lmachu	wxn	mλm	nzm	pheu	vxu	23.0	nzn	cplinu	cpslnu	cp2ndu	cpi
lmachl	wxl	wyl	wzl	phel	vxl	vyl	vzl	cplinl	cpslnl	cp2ndl	cpi
num pus	wnl	numd	pwn1	vtu	vtl	pvtu	pvtl	cplind	cpslnd	cp2ndd	cpi
24 11	39.3297	5.3900	-4.2074	0.6593	-0.0025	0.0030	-0.0026	0.0000	0.0000	0.0178	0
0.7787	0.9917	-0.0043	0.0034	-0.3620	0.9760	-0.0043	0.0028	0.0490	0.0480	0.0478	0
0.7810	0.9925	-0.0073	0.0059	-1.0213	0.9785	-0.0073	0.0054	0.0438	0.0429	0.0427	0
0.0000	0.0000	-0.0269	-0.0269	0.9760	0.9786	0.0291	0.0247	0.0053	0.0052	0.0051	0
25 12	36.9972	5.3901	-4.2069	0.6518	9600.0	-0.0072	0.0063	0.0000	0000.0	0.0178	0
0.7863	0.9946	-0.0095	0.0077	-0.3185	0.9844	-0.0095	0.0073	0.0318	0.0310	0.0309	0
0.7778	0.9913	-0.0022	0.0017	-0.9703	0.9749	-0.0022	0.0011	0.0514	0.0503	0.0500	0
0.000	0000	0 0 0 0	0,000	24000							

	34 19	0.0000	0.7768	0.7750	33 18	0.0000	0.7717	0.7693	32 17	0.0000	0.7257	0.8544	29 16	0.0000	0.7561	0.8146	28 15 0212	0.0000	0.7665	0.8018	27 14	0.0000	0.7728	0.7937	26 13	. 0191	Mar. 7 1996 13:51
	39.8703	0.0000	0.9909	0.9901	41.9658	0.0000	0.9887	0.9878	44.0611	0.0000	0.9693	1.0192	27.6671	0.0000	0.9825	1.0054	29.9996	0.0000	0.9867	1.0006	32.3324	0.0000	0.9893	0.9975	34.6651		
	6.8942	-0.0269	-0.0050	-0.0073	6.8941	-0.0271	-0.0062	-0.0034	6.8941	-0.0268	0.0373	-0.0565	5.3902	-0.0270	0.0119	-0.0279	5.3903	-0.0269	0.0053	-0.0194	5.3902	-0.0269	0.0017	-0.0143	5.3901		
	-5.4653	-0.0269	0.0040	0.0058	-5.4660	-0.0271	0.0047	0.0023	-5.4668	-0.0268	-0.0312	0.0472	-4.2053	-0.0270	-0.0101	0.0231	-4.2057	-0.0269	-0.0047	0.0160	-4.2061	-0.0269	-0.0016	0.0117	-4.2065		
	0.6513	0.9717	-1.0521	-0.4002	0.6518	0.9652	-1.1105	-0.4654	0.6451	1.0578	-0.5933	-0.3662	0.2271	1.0159	-0.7299	-0.3068	0.4231	1.0019	-0.8284	-0.2881	0.5403	0.9929	-0.9070	-0.2934	0.6136		
	0.0039	0.9738	0.9738	0.9717	-0.0021	0.9679	0.9679	0.9651	-0.0028	0.9130	0.9116	1.0551	0.1435	0.9498	0.9496	1.0152	0.0656	0.9618	0.9618	1.0016	0.0398	0.9692	0.9692	0.9928	0.0236		results
	-0.0078	0.0308	-0.0050	-0.0073	-0.0022	0.0391	-0.0062	-0.0034	0.0028	0.0763	0.0373	-0.0565	-0.0939	0.0211	0.0119	-0.0279	-0.0397	0.0036	0.0053	-0.0194	-0.0247	0.0077	0.0017	-0.0143	-0.0160		
	0.0066	0.0304	0.0034	0.0052	0.0018	0.0349	0.0040	0.0016	-0.0024	0.1137	-0.0333	0.0485	0.0817	0.0630	-0.0113	0.0234	0.0347	0.0481	-0.0055	0.0160	0.0216	0.0393	-0.0023	0.0116	0.0139		
	0.0000	0.0041	0.0534	0.0574	0.0000	0.0057	0.0651	0.0708	0.0000	-0.2925	0.1801	-0.1124	0.0000	-0.1335	0.1027	-0.0308	0.0000	-0.0810	0.0780	-0.0031	0.0000	-0.0481	0.0630	0.0149	0.0000		
,	0.0000	0.0041	0.0524	0.0565	0.0000	0.0056	0.0641	0.0697	0.0000	-0.2902	0.1745	-0.1157	0.0000	-0.1323	0.1006	-0.0317	0.0000	-0.0802	0.0764	-0.0038	0.0000	-0.0475	0.0617	0.0141	0.0000		
	0.0160	0.0041	0.0521	0.0562	0.0160	0.0055	0.0638	0.0693	0.0160	-0.2884	0.1716	-0.1169	0.0177	-0.1314	0.0996	-0.0318	0.0177	-0.0797	0.0759	-0.0038	0.0177	-0.0472	0.0613	0.0141	0.0178		P
147	0	0	0	0	0	0	0	0	0	-0	0	-0	0	-0	0	-0	0	-0	0	-0	0	-0	0	0	0		Page 147

Page 148	0	0	0-	0	0	0	0 -	00	rd	cpi	cpi	cpi	0	0	0	0	0	0-	0	0-	0	0-	0	0	0
Pa	0.0418	0.0498	-0.0080	0.0159	0.0267	0.0542	-0.0275	columns =	any	cp2ndu	cp2ndl	cp2ndd	0.0159	0.0109	0.0631	-0.0522	0.0159	-0.0074	0.0766	-0.0840	0.0159	-0.0373	0.1013	-0.1386	0.0159
	0.0420	0.0500	-0.0081	0.0000	0.0268	0.0545	-0.0277	number columns	anx	cpslnu	cpslnl	cpslnd	0.000	0.0109	0.0635	-0.0526	0.0000	-0.0074	0.0772	-0.0846	0.0000	-0.0371	0.1023	-0.1394	0.0000
	0.0428	0.0511	-0.0083	0.000	0.0275	0.0557	-0.0281	rows = 8	08	cplinu	cplinl	cplind	0.0000	0.0117	0.0648	-0.0532	0.0000	-0.0066	0.0788	-0.0854	0.0000	-0.0360	0.1046	-0.1406	0.0000
	0.0082	0.0016	0.0309	0.0115	0.0112	-0.0003	0.0345	number rows	z p	nzn	vzl	pvtl	0.0170	0.0143	-0.0027	0.0402	0.0247	0.0187	-0.0060	0.0487	0.0395	0.0271	-0.0124	0.0649	0.0926
	-0.0109	-0.0031	0.0223	-0.0133	-0.0140	-0.0007	0.0137	type = 12	dy	n.V.	vyl	pvtu	-0.0197	-0.0179	0.0018	0.0051	-0.0284	-0.0229	0.0055	0.0081	-0.0454	-0.0320	0.0133	0.0268	-0.1066
results	0.9789	0.9750	0.9750	0.0137	0.9864	0.9728	0.9728	doublet	ੜ੍ਹ	nxn	vxl	vtl	0.0260	0.9943	0.9683	0.9683	0.0419	1.0033	0.9614	0.9614	0.0690	1.0177	0.9487	0.9489	0.1566
	-0.3496	-1.0010	0.9790	0.6334	-0.3148	-0.9483	0.9866	type = 0	q ₀	pheu	phel	vtu	0.5927	-0.2957	-0.8884	0.9945	0.5225	-0.2942	-0.8167	1.0037	0.4118	-0.3148	-0.7266	1.0186	0.2250
	9800.0	0.0021	-0.0271	-5.4646	0.0115	0.0004	-0.0270	1 source	z	wzn	wzl	pwnl	-5.4639	0.0144	-0.0020	-0.0271	-5.4630	0.0186	-0.0051	-0.0271	-5.4624	0.0267	-0.0112	-0.0268	-5.4617
	-0.0109	-0.0031	-0.0271	6.8943	-0.0140	-0.0007	-0.0270	index:	>-	nAm	wyl	numd	6.8943	-0.0179	0.0018	-0.0271	6.8944	-0.0229	0.0055	-0.0271	6.8943	-0.0320	0.0133	-0.0268	6.8939
	0.9926	0.9913	0.000.0	37.7751	0.9952	9066.0	0.000.0	:. eri	×	wxu	wxl	wnl	35.6799	0.9980	0.9890	0.0000	33.5845	1.0011	0.9866	0.0000	31.4892	1.0062	0.9822	0.0000	29.3942
Mar 7 1996 13:51	0.7814	0.7779	00000.0	35 20	0.7881	0.7759	0.0000	1 network id:	di of	lmachu	lmachl	num pus	36 21	0.7952	0.7720	0.0000	37 22	0.8034	0.7661	0.0000	38 23	0.8171	0.7554	0.0000	39 24 .0191

-0 0	0 0795		0 0808	-0.0070	0.0066	0.9604	-0.8037	-0.0061	0.0066	2980 0	.0106
0	-0.0106	-0.0106	-0.0098	0.0209	-0.0256	1.0048	-0.3059	0.0208	-0.0256	1.0016	0.8049
	0.0141	0.0000	0.0000	0.0279	-0.0322	0.0443	0.4978	-6.7200	8.3984	34.8366	47 30
-0	-0.0566	-0.0570	-0.0576	0.0420	0.0057	0.9672	0.9957	-0.0272	-0.0272	0.0000	.0565
. 0	0.0652	0.0656	0.0670	-0.0037	0.0029	0.9672	-0.8690	-0.0030	0.0029	0.9887	0.7711
. 0	0.0086	0.0086	0.0093	0.0166	-0.0206	0.9954	-0.3050	0.0167	-0.0206	0.9983	0.7962
0	0.0141	0.0000	0.0000	0.0203	-0.0236	0.0281	0.5641	-6.7211	8.3986	36.6947	46 29
-0	-0.0324	-0.0327	-0.0332	0.0370	0.0118	0.9715	0.9878	-0.0272	-0.0272	0.0000	.0324
0	0.0568	0.0571	0.0584	-0.0019	0.0009	0.9715	-0.9243	-0.0013	0.0009	0.9901	0.7748
0	0.0243	0.0244	0.0251	0.0137	-0.0174	0.9876	-0.3198	0.0140	-0.0174	0.9956	0 7892
0	0.0141	0.0000	0.0000	0.0156	-0.0183	0.0161	0.6045	-6.7221	8.3985	38.5529	45 28
-0	-0.0153	-0.0154	-0.0159	0.0347	0.0189	0.9733	0.9810	-0.0272	-0.0272	0.0000	.0352
0	0.0533	0.0535	0.0547	-0.0010	-0.0002	0.9733	-0.9737	-0.0004	-0.0002	0.9908	0.7764
0	0.0380	0.0381	0.0388	0.0116	-0.0150	0.9808	-0.3482	0.0120	-0.0150	0.9932	0.7831
0	0.0141	0.0000	0.0000	0.0126	-0.0148	0.0075	0.6254	-6.7230	8.3984	40.4108	44 27
-0	-0.0049	-0.0050	-0.0054	0.0349	0.0256	0.9723	0.9748	-0.0272	-0.0272	0.0000	0.0000
0	0.0551	0.0554	0.0566	-0.0005	-0.0008	0.9723	-1.0224	0.0001	-0.0008	0.9904	0.7756
0	0.0502	0.0504	0.0512	0.0093	-0.0125	0.9747	-0.3885	0.0099	-0.0125	0.9910	0.7777
0	0.0141	0.0000	0.0000	0.0098	-0.0117	0.0024	0.6339	-6.7242	8.3986	42.2688	43 26
-0	-0.0005	-0.0005	-0.0009	0.0380	0.0321	0.9688	0.9690	-0.0272	-0.0272	0.0000	0.0000
0	0.0621	0.0625	0.0637	-0.0009	-0.0005	0.9688	-1.0752	-0.0002	-0.0005	0.9891	0.7725
0	0.0616	0.0620	0.0628	0.0071	-0.0100	0.9689	-0.4399	0.0078	-0.0100	0.9890	0.7726
0	0.0142	0.0000	0.0000	0.0080	-0.0095	0.0002	0.6354	-6.7254	8.3988	44.1269	42 25
-0	-0.3154	-0.3172	-0.3195	0.1227	0.0883	0.9077	1.0659	-0.0270	-0.0270	0.0000	.1810 0.0000
0	0.1819	0.1852	0.1919	-0.0380	0.0427	0.9059	-0.6004	-0.0359	0.0427	0.9673	.1332
-0	-0.1335	-0.1320	-0.1277	0.0545	-0.0639	1.0626	-0.3754	0.0531	-0.0639	1.0217	0.8624

0	00	rd	cpi	cpi	cpi	0	0-	0	0	0	0-	0	0	0	0	0	0 -	0	0	0	0	0	0	0
-0.0891	columns =	any	cp2ndu	cp2ndl	cp2ndd	0.0141	-0.0429	0.1047	-0.1477	0.0141	-0.1486	0.1926	-0.3411	0.0123	0.0554	0.0586	-0.0032	0.0123	0.0455	0.0550	-0.0095	0.0123	0.0354	0.0540
-0.0897	number	anx	cpslnu	cpslnl	cpslnd	0.0000	-0.0428	0.1058	-0.1486	0.0000	-0.1468	0.1963	-0.3431	0.0000	0.0557	0.0589	-0.0032	0.0000	0.0457	0.0553	9600.0-	0.0000	0.0355	0.0543
-0.0905	rows = 8	08	cplinu	cplinl	cplind	0.0000	-0.0415	0.1082	-0.1497	0.0000	-0.1415	0.2040	-0.3455	0.0000	0.0564	0.0604	-0.0040	0.0000	0.0465	0.0568	-0.0103	0.0000	0.0362	0.0557
0.0503	number	dz	nzn	vzl	pvtl	0.0435	0.0295	-0.0140	0.0677	0.1013	0.0590	-0.0423	0.1312	0.0165	0.0116	-0.0048	0.0407	0.0173	0.0131	-0.0043	0.0386	0.0187	0.0150	-0.0037
0.0120	type = 12	dy	250	vyl	pvtu	-0.0501	-0.0352	0.0149	0.0315	-0.1168	-0.0695	0.0473	0.0981	-0.0196	-0.0154	0.0042	0.0276	-0.0206	-0.0174	0.0032	0.0225	-0.0221	-0.0189	0.0033
0.9605	doublet	ð	nxn	vxl	vtl	0.0734	1.0203	0.9469	0.9472	0.1693	1.0693	0.9000	0.9023	0.0014	0.9720	0.9705	90.9706	0.0046	0.9769	0.9723	0.9724	0.0091	0.9820	0.9729
1.0053	source type = 0	d0	pheu	phel	vtu	0.3938	-0.3278	-0.7216	1.0214	0.2164	-0.3883	-0.6047	1.0732	0.5979	-0.4289	-1.0269	0.9722	0.5938	-0.3883	-0.9821	0.9772	0.5827	-0.3562	-0.9389
-0.0272	1 source	2	nzn	wzl	pwnl	-6.7188	0.0291	-0.0128	-0.0270	-6.7179	0.0574	-0.0400	-0.0272	-7.9837	0.0123	-0.0041	-0.0272	-7.9822	0.0136	-0.0036	-0.0275	-7.9807	0.0154	-0.0031
-0.0272	index:	7	mXm	wyl	numd	.8.3980	-0.0352	0.0149	-0.0270	8.3979	-0.0695	0.0473	-0.0272	9.9036	-0.0154	0.0042	-0.0272	9.9034	-0.0174	0.0032	-0.0275	9.9029	-0.0189	0.0033
0.0000		×	wxn	wxl	wnl	32.9791	1.0071	0.9816	0.0000	31.1216	1.0241	0.9653	0.0000	44.1925	0.9900	6686.0	0.0000	42.5718	0.9918	0.9905	0.0000	40.9511	0.9935	0.9907
.0784 0.0000	network id:	jc ip	lmachu	lmachl snl	num pus	48 31	0.8197	0.7540	0.0000	49 32	0.8697	0.7171	0.0000	52 33	0.7754	0.7741	0.0000	53 34	0.7797	0.7756	0.0000.	54 35	0.7842	0.7761

	wnu	lmachl	lmachu	nz je j	1 netv	3666	2032	0	0148	.1571	.1088	0.8	0148	.0939	. 0805		.0148	.0591	0.662	0071	01 48	0.0	0	0	0148	.0186	Mar 7 1996 13:51
	L		L	ίp	network id:	0.0000	0.7122	8773	40	0.0000	0.7521	0.8222	39	0.0000	0.7644	8062	38	0.0000	0.7707	0.7969	37	0.0000	7747	7896	36	0.0000	6 13:51
	wnl	wxl	ихи	×		0.0000	0.9630	1.0265	32.8484	0.0000	0.9808	1.0079	34.4689	0.0000	0.9859	1.0021	36.0892	0.0000	0.9885	0.9985	37.7098	0.0000	0.9901	0.9957	39.3304	0.0000	
	numd	wy1	wyu	¥	index:	-0.0275	0.0522	-0.0749	9.9021	-0.0273	0.0169	-0.0380	9.9023	-0.0273	0.0082	-0.0281	9.9027	-0.0275	0.0046	-0.0235	9.9028	-0.0275	0.0031	-0.0208	9.9027	-0.0271	
	pwnl	wzl	mzm	и	1 sourc	-0.0275	-0.0444	0.0615	-7.9739	-0.0273	-0.0148	0.0311	-7.9753	-0.0273	-0.0075	0.0228	-7.9767	~0.0275	-0.0047	0.0187	-7.9781	-0.0275	-0.0035	0.0164	-7.9795	-0.0271	
	vtu	phel	pheu	do	source type = 0	1.0807	-0.6072	-0.4030	0.2042	1.0241	-0.7146	-0.3443	0.3703	1.0067	-0.7885	-0.3224	0.4661	0.9964	-0.8469	-0.3200	0.5269	0.9883	-0.8956	-0.3323	0.5632	0.9822	
	vt1	vxl	νχυ	d _x	doublet	0.8962	0.8934	1.0762	0.1828	0.9450	0.9447	1.0229	0.0782	0.9594	0.9593	1.0060	0.0467	0.9667	0.9667	0.9960	0.0293	0.9713	0.9713	0.9879	0.0167	0.9729	resuits
	pvtu	3 21	ZŽ.	dу	type = 12	0.1078	0.0522	-0.0749	-0.1270	0.0359	0.0169	-0.0380	-0.0549	0.0154	0.0082	-0.0281	-0.0362	0.0083	0.0046	-0.0235	-0.0281	0.0121	0.0031	-0.0208	-0.0239	0.0175	
	pvtl	vzl	vzu	dz	number	0.1406	-0.0468	0.0632	0.1100	0.0712	-0.0160	0.0316	0.0476	0.0525	-0.0084	0.0229	0.0313	0.0440	-0.0055	0.0186	0.0241	0.0393	-0.0042	0.0162	0.0204	0.0380	
	cplind	cplinl	cplinu	s0	rows = 8	-0.3731	0.2175	-0.1555	0.0000	-0.1595	0.1128	-0.0467	0.0000	-0.0955	0.0831	-0.0124	0.0000	-0.0603	0.0682	0.0080	0.0000	-0.0347	0.0589	0.0242	0.0000	-0.0195	
	cpslnd	cpslnl	cpslnu	anx		-0.3705	0.2087	-0.1618	0.0000	-0.1583	0.1101	-0.0482	0.0000	-0.0946	0.0812	-0.0134	0.0000	-0.0595	0.0667	0.0071	0.0000	-0.0340	0.0575	0.0234	0.0000	-0.0188	
	cp2ndd	cp2nd1	cp2ndu	any	number columns =	-0.3684	0.2045	-0.1640	0.0123	-0.1574	0.1090	-0.0484	0.0123	-0.0940	0.0806	-0.0134	0.0123	-0.0591	0.0662	0.0071	0.0123	-0.0338	0.0571	0.0234	0.0123	-0.0186	32
151	cpi	cpi	cpi	עם	ω	-0	0	-0	0	-0	0	-0	0	-0	0	-0	0	-0	0	0	0	-0	0	0	0	-0	Page 151

Page 152		0	0	0	0-	0	0	0	0-	0	0	0	0	0	0	0	0	0	0	0	0-	0	0 -	0	0-	0
Pag		0.0105	0.0497	0.0541	-0.0043	0.0105	0.0418	0.0528	-0.0110	0.0105	0.0341	0.0521	-0.0180	0.0105	0.0241	0.0549	-0.0308	0.0105	0.0080	0.0647	-0.0566	0.0105	-0.0138	0.0807	-0.0945	0.0105
		0.000.0	0.0500	0.0544	-0.0044	0.000.0	0.0420	0.0530	-0.0111	0.000.0	0.0342	0.0524	-0.0182	0.000.0	0.0241	0.0552	-0.0311	0.000.0	0.0080	0.0651	-0.0570	0.0000	-0.0138	0.0814	-0.0952	0.0000
		0.000.0	0.0508	0.0564	-0.0056	0.000.0	0.0428	0.0550	-0.0122	0.0000	0.0350	0.0542	-0.0192	0.0000	0.0250	0.0570	-0.0320	0.0000	0.0000	0.0669	-0.0579	0.000	-0.0127	0.0834	-0.0962	0.0000
		0.0265	0.0168	-0.0097	0.0447	0.0267	0.0177	0600.0-	0.0432	0.0269	0.0192	-0.0077	0.0421	0.0276	0.0196	-0.0080	0.0426	0.0300	0.0214	-0.0086	0.0465	0.0357	0.0251	-0.0106	0.0548	0.0517
		-0.0316	-0.0220	9600.0	0.0253	-0.0318	-0.0235	0.0083	0.0219	-0.0320	-0.0240	0.0080	0.0189	-0.0326	-0.0255	0.0071	0.0154	-0.0352	-0.0275	0.0077	0.0131	-0.0415	-0.0309	0.0106	0.0187	-0.0598
results		0.0019	0.9746	0.9728	0.9729	0.0052	0.9786	0.9734	0.9735	0.0087	0.9824	0.9738	0.9738	0.0150	0.9874	0.9724	0.9724	0.0279	0.9954	0.9674	0.9675	0.0469	1.0061	0.9593	0.9594	0.0821
		0.5332	-0.4324	-0.9657	0.9750	0.5290	-0.4007	-0.9297	0.9790	0.5189	-0.3750	-0.8939	0.9829	0.5042	-0.3543	-0.8584	0.9879	0.4755	-0.3428	-0.8183	0.9960	0.4248	-0.3443	-0.7691	1.0069	0.3406
		-9.2422	0.0173	-0.0091	-0.0276	-9.2404	0.0182	-0.0084	-0.0279	-9.2387	0.0196	-0.0071	-0.0271	-9.2370	0.0199	-0.0073	-0.0279	-9.2351	0.0215	-0.0079	-0.0279	-9.2334	0.0250	9600.0-	-0.0274	-9.2317
		11.4079	-0.0220	9600.0	-0.0276	11.4079	-0.0235	0.0083	-0.0279	11.4075	-0.0240	0.0080	-0.0271	11.4070	-0.0255	0.0071	-0.0279	11.4071	-0.0275	0.0077	-0.0279	11.4069	-0.0309	0.0106	-0.0274	11.4065
		44.2579	6066.0	0.9908	0.0000	42.8745	0.9923	0.9910	0.000.0	41.4910	0.9936	0.9911	0.000.0	40.1079	0.9954	9066.0	0.000.0	38.7248	0.9982	0.9888	0.0000	37.3418	1.0020	0.9859	0.0000	35.9585
96 13:51		41	0.7779	0.7761	0000	42	0.7814	0.7767	0000	43	0.7848	6911	0000	44	0.7893	0.7757	0000	4.5	0.7965	0.7714	0000	46	0.8064	0.7644	0000	47
Mar 7 1996 13:51	snd	62	0497	0540	0.0000	63	0418	0527	00000.0	64	0347	0.7769	0.0000	65	0241	0549	00000.0	66	OURU	0646	0.0000.	67	0138	0806	0.0000	68

75 52 .0104	0.0000	0.7790	0.7852	74 51	snd	lmachl	nz lmachu	jc ip	network id:	0.0000	0.7789	0.7828	73 50	0.0000	0.7788	0.7803	72 49	0.0000	0.7067	0.8855	69 48	.1651	0.7506	.0126
2 40.8853	0 0.0000	0 0.9920	2 0.9934	1 42.0309	wnl	wxl	wxu	×	k id:	0.0000	0.9920	0.9924) 43.1771	0.0000	0.9919	0.9914	44.3232	0.0000	0.9604	1.0291	34.5750	0.0000	0.9801	1.0086
12.9116	-0.0278	0.0183	-0.0354	12.9120	numd	wy1	wyu	×	index:	-0.0281	0.0193	-0.0352	12.9122	-0.0278	0.0204	-0.0341	12.9125	-0.0279	0.0575	-0.0806	11.4064	-0.0277	0.0190	-0.0408
-10.4945	-0.0278	-0.0167	0.0282	-10.4967	pwnl	wzl	wzw	2	1 sour	-0.0281	-0.0179	0.0277	-10.4987	-0.0278	-0.0185	0.0272	-10.5007	-0.0279	-0.0493	0.0657	-9.2298	-0.0277	-0.0170	0.0328
0.4102	0.9833	-0.8309	-0.4115	0.4194	vtu	phel	pheu	d0	source type =	0.9805	-0.8581	-0.4325	0.4256	0.9777	-0.8854	-0.4570	0.4285	1.0887	-0.6081	-0.4193	0.1888	1.0262	-0.7048	-0.3642
0.0110	0.9760	0.9757	0.9822	0.0065	vt1	vx1	vxu	ę,	0 doublet	0.9759	0.9755	0.9795	0.0040	0.9757	0.9753	0.9768	0.0014	0.8892	0.8859	1.0836	0.1978	0.9431	0.9427	1.0248
-0.0534	0.0284	0.0183	-0.0354	-0.0537	pvtu	٧٧٢	עאַע	dу	t type = 12	0.0297	0.0193	-0.0352	-0.0545	0.0308	0.0204	-0.0341	-0.0546	0.1182	0.0575	-0.0806	-0.1381	0.0396	0.0190	-0.0408
0.0448	0.0530	-0.0172	0.0278	0.0450	pvtl	vz1	vzu	dz	number	0.0545	-0.0184	0.0272	0.0457	0.0557	-0.0190	0.0267	0.0457	0.1511	-0.0519	0.0676	0.1195	0.0747	-0.0183	0.0334
0.0000	-0.0162	0.0509	0.0348	0.0000	cplind	cplinl	cplinu	s0	rows =	-0.0112	0.0515	0.0403	0.0000	-0.0060	0.0519	0.0458	0.0000	-0.4036	0.2330	-0.1707	0.0000	-0.1677	0.1170	-0.0507
0.0000	-0.0145	0.0480	0.0335	0.0000	cpslnd	cpslnl	cpslnu	anx	8 number	-0.0093	0.0484	0.0390	0.0000	-0.0040	0.0486	0.0446	0.0000	-0.4009	0.2228	-0.1780	0.0000	-0.1664	0.1140	-0.0524
0.0087	-0.0144	0.0477	0.0334	0.0087	cp2ndd	cp2nd1	cp2ndu	any	number columns =	-0.0093	0.0481	0.0389	0.0087	-0.0040	0.0484	0.0444	0.0087	-0.3986	0.2179	-0.1807	0.0105	-0.1654	0.1127	-0.0526
	1			_	cpi	cp1	cp1	Qu.	00	-0	0	0	0	-0	0	0	0	-0	0	-0	0	-0	0	-0

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0.7885	0.9947	-0.0361	0.0283	-0.3936	0.9859	-0.0361	0.0280	0.0275	0.0262	0.0261	0
0.7782	0.9917	0.0172	-0.0162	-0.8038	0.9748	0.0172	-0.0168	0.0527	0.0498	0.0495	0
0.0000	0.0000	-0.0282	-0.0282	0.9869	0.9751	0.0269	0.0524	-0.0252	-0.0236	-0.0234	0-
76 53	39.7398	12.9114	-10.4924	0.3929	0.0211	-0.0536	0.0452	0 . 0000	0.000.0	0.0087	0
0.7941	0.9969	-0.0368	0.0290	-0.3813	0.9921	-0.0368	0.0288	0.0150	0.0136	0.0135	0
0.7749	0.9903	0.0168	-0.0157	-0.7742	0.9711	0.0168	-0.0164	0.0602	0.0574	0.0571	0
0.0000	0.0000	-0.0281	-0.0281	0.9932	0.9713	0.0254	0.0538	-0.0452	-0.0438	-0.0435	0-
77 54	38.5940	12.9110	-10.4904	0.3601	0.0390	-0.0560	0.0477	0.0000	0.000	0.0087	0
0.8033	1.0005	-0.0382	0.0309	-0.3780	1.0022	-0.0382	0.0309	-0.0053	-0.0068	-0.0068	0-
0.7680	0.9875	0.0178	-0.0159	-0.7382	0.9632	0.0178	-0.0167	0.0760	0.0732	0.0726	0
0.0000	0.0000	-0.0276	-0.0276	1.0034	0.9635	0.0269	0.0591	-0.0813	-0.0800	-0.0794	0-
78 55	37.4480	12.9106	-10.4883	0.2983	0.0783	-0.0700	0.0601	0.0000	0.0000	0.0087	0
0.8227	1.0078	-0.0463	0.0364	-0.3905	1.0228	-0.0463	0.0369	-0.0470	-0.0491	-0.0493	0-
0.7523	0.9809	0.0238	-0.0219	-0.6887	0.9445	0.0238	-0.0232	0.1138	0.1101	0.1089	0
0.0000	0.0000	-0.0285	-0.0285	1.0245	0.9451	0.0437	0.0780	-0.1608	-0.1592	-0.1583	0-
79 56	36.3021	12.9107	-10.4861	0.1687	0.2123	-0.1512	0.1306	0.0000	0.0000	0.0087	0
0.8937	1.0315	-0.0871	0.0708	-0.4378	1.0907	-0.0871	0.0728	-0.1852	-0.1940	-0.1970	0-
0.7016	0.9578	0.0641	-0.0550	-0.6066	0.8784	0.0641	-0.0578	0.2483	0.2364	0.2309	0
0.0000	0.0000	-0.0282	-0.0282	1.0966	0.8826	0.1291	0.1625	-0.4335	-0.4304	-0.4279	0
82 57	44.3885	14.4174	-11.7593	0.2395	-0.0004	-0.1363	0.1141	0.0000	0.0000	0.0069	0
0.7852	0.9910	-0.0761	0.0613	-0.5250	0.9777	-0.0761	0.0609	0.0415	0.0350	0.0349	0
0.7847	0.9937	0.0602	-0.0526	-0.7644	0.9781	0.0602	-0.0532	0.0487	0.0375	0.0373	0
00000	0.0000	-0.0285	-0.0285	0.9826	0.9814	0.0781	0.1049	-0.0072	-0.0025	-0.0024	0
83 58	43.4799	14.4169	-11.7570	0.2381	0.0018	-0.1356	0.1135	0.0000	0.0000	0.0069	0
0.7872	0.9918	-0.0760	0.0618	-0.5067	0.9799	-0.0760	0.0614	0.0371	0.0306	0.0305	0
0.7846	0.9936	0.0596	-0.0515	-0.7448	0.9780	0.0596	-0 0521	0 0487	0,00	6	

	0	0083	.0317			. 0083	.0193	0	0	0083	snd	lmachl snl	lmachu	jc j	neti	.0135	0.7		0083	0	0366		0083	.0374
7706	8084	63	0.0000	7817	7955	62	0.0000	7841	7923	61	-	Ġ	_	ip	network id:	0000	0.7848	7903	60	0000	0.7849	7886	59	0000
0.9881	1.0005	38.9378	0.0000	0.9927	0.9954	39.8463	0.0000	0.9936	0.9939	40.7547	wnl	wxl	wxu	×	ď.	0.0000	0.9938	0.9931	41.6630	0.0000	0.9938	0.9923	42.5713	0.0000
0.0513	-0.0738	14.4150	-0.0282	0.0523	-0.0731	14.4154	-0.0285	0.0550	-0.0752	14.4158	numd	wy1	wyu	۲	index:	-0.0286	0.0568	-0.0762	14.4162	-0.0289	0.0580	-0.0766	14.4167	-0.0281
-0.0454	0.0587	-11.7451	-0.0282	-0.0454	0.0591	-11.7475	-0.0285	-0.0480	0.0605	-11.7497	pwnl	wzl	MZM	74	1 sour	-0.0286	-0.0498	0.0612	-11.7521	-0.0289	-0.0512	0.0612	-11.7548	-0.0281
-0.6439	-0.4450	0.1989	0.9942	-0.6683	-0.4498	0.2185	0.9905	-0.6884	-0.4606	0.2278	vtu	phel	pheu	0D	source type = (0.9883	-0.7072	-0.4741	0.2332	0.9863	-0.7260	-0.4894	0.2366	0.9848
0.9631	1.0040	0.0410	0.9783	0.9758	0.9898	0.0140	0.9808	0.9780	0.9858	0.0077	vtl	vx1	vxu	ę,	0 doublet	0.9815	0.9786	0.9834	0.0049	0.9816	0.9785	0.9815	0.0029	0.9812
0.0513	-0.0738	-0.1251	0.0722	0.0523	-0.0731	-0.1254	0.0752	0.0550	-0.0752	-0.1302	pvtu	vy1	ıyçı	dу	: type = 12	0.0768	0.0568	-0.0762	-0.1330	0.0775	0.0580	-0.0766	-0.1345	0.0778
-0.0463	0.0589	0.1052	0.0950	-0.0460	0.0589	0.1050	0.0980	-0.0486	0.0603	0.1088	pvt1	vz1	NZU	dz	number	0.1004	-0.0503	0.0609	0.1112	0.1021	-0.0517	0.0608	0.1125	0.1037
0.0783	-0.0109	0.0000	-0.0353	0.0529	0.0176	0.0000	-0.0231	0.0485	0.0254	0.0000	cplind	cplinl	cplinu	s0	rows =	-0.0175	0.0476	0.0301	0.0000	-0.0137	0.0477	0.0340	0.0000	-0.0116
0.0693	-0.0170	0.0000	-0.0321	0.0437	0.0116	0.0000	-0.0195	0.0386	0.0191	0.0000	cpslnd	cpslnl	cpslnu	anx	8 number	-0.0137	0.0372	0.0235	0.0000	-0.0095	0.0370	0.0275	0.0000	-0.0072
0.0687	-0.0170	0.0069	-0.0318	0.0435	0.0116	0.0069	-0.0194	0.0384	0.0190	0.0069	cp2ndd	cp2nd1	cp2ndu	any	number columns =	-0.0136	0.0370	0.0235	0.0069	-0.0094	0.0368	0.0274	0.0069	-0.0071
0	-0	0	-0	0	0	0	-0	0	0	0	cp1	cpi	cpi	ρu	œ	-0	0	0	0	-0	0	0	0	-0

Mar 7 1006 12-81				*Boulto					(6.45)	(aida
ואומו ז ושפט ומיסו				Since					L	Hage 150
0.0000 0.0000	-0.0289	-0.0289	1.0085	0.9655	0.0722	0.0983	-0.0892	-0.0862	-0.0857	0
89 64 38.0294	14.4148	-11.7426	0.1326	0.1914	-0.1885	0.1613	0.0000	0.0000	0.0069	0
0.8864 1.0273	-0.1057	0.0857	-0.4642	1.0800	-0.1057	0.0876	-0.1647	-0.1784	-0.1808	0-
0.7126 0.9618	0.0828	-0.0712	-0.5968	0.8886	0.0828	-0.0738	0.2290	0.2112	0.2065	0
0.0000 0.0000	-0.0286	-0.0286	1.0887	0.8955	0.1404	0.1732	-0.3937	-0.3896	-0.3873	0-
1 0*b*for-mom-net#- 1			force / moment data for notunely	t data for	0 2 7 7	-				
				יר ממכמ דמו	V 10 M 10	4				
totals for column	1	area	fx	fy	44	fz	жш	my	ZW	
α		40.29655	0.00000	-0.00355		-0.00424	-0.02639	-0.01477		0.0123
· .		40.29655	0.00000	0.00999	666	0.01196	0.07635	0.05750		-0.0480
,		40.29655	0.00000	0.00644	544	0.00771	0.04996	0.04273		-0.0356
totals for column	7	area	fx	fγ	ч	fz	TIX.	мУ	шz	
σ-		36.57013	0.00000	-0.00156		-0.00186	-0.01623	-0.00475		0.0039
		36.57013	0.0000	0.01074	174	0.01285	0.11449	0.05956		-0.0497
6		36.57013	0.00000	0.00918	118	0.01099	0.09826	0.05481		-0.0457
totals for column	m.	area	fx	fy	4	fz	TUX.	му	ZW	
,		32.84674	0.00000	-0.00043		-0.00051	-0.00566	0.00065		-0.0005
ı m		32.84674	0.00000	0.01025	25	0.01227	0.14047	0.05580		-0.0466
S		32.84674	0.00000	0.00982	182	0.01176	0.13480	0.05644		-0.0471
totals for column	4	area	fx	fy	ч	fz	тх	Кш	zw	
		29.12062	0.00000	0.00028	128	0.00034	0.00478	0.00379		-0.0031

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o un		29.12062	0.00001	0.00945	0.01131	0.15828	0.05062	-0.0422
Ν α		29.12062	0.00001	0.00972	0.01165	0.16305	0.05440	-0.0454
totals for column	ъ	area	fx	£У	rf N	m _X	my	mz
n		25.40189	0.00000	0.00073	0.00088	0.01453	0.00560	-0.0046
ω (25.40189	0.00001	0.00845	0.01012	0.16733	0.04459	-0.0372
00 L		25.40189	0.00001	0.00917	0.01100	0.18186	0.05018	-0.0418
totals for column	Ø	area	fx	fу	Ff. N	mx	my	mz
		21.67510	0.00000	0.00094	0.00114	0.02161	0.00619	-0.0051
· •		21.67510	0.00001	0.00726	0.00870	0.16598	0.03775	-0.0315
o 1		21.67510	0.00001	0.00820	0.00984	0.18759	0.04394	-0.0366
	1		1					
			:	į	;	•	å	į
n.		17.95490	0.00000	0.00085	0.00103	0.02206	0.00525	-0.0043
э (17.95490	0.00001	0.00580	0.00695	0.14997	0.02966	-0.0247
N		17.95490	0.00001	0.00665	0.00797	0.17204	0.03491	-0.0291
totals for column	œ	area	fx	fy	r N	mx	my	mz
Α		14.22880	0.00000	0.00037	0.00045	0.01058	0.00233	-0.0019
0		14.22880	0.00001	0.00352	0.00422	0.10168	0.01772	-0.0147
ω ·		14.22880	0.00001	0.00389	0.00467	0.11226	0.02005	-0.0167
totals for network		area	fx	fy	fz	ж	ту	mz
vo		218.09473	0.00000	-0.00237	-0.00279	0.02527	0.00427	-0.0033
		218.09473	0.00005	0.06546	0.07837	1.07455	0.35320	-0.2950
								157

					elinear						rage 150
			218.09473	0.00006		0.06308	0.07559	1.09982	0.35747	•	-0.2984
totals for all networks so	l networks	so far	area	fx	fλ		ZJ	ж	Δm	mZ	N
			218.09473	0.00000		-0.00237	-0.00279	0.02527	0.00427		-0.0033
			218.09473	0.00005		0.06546	0.07837	1.07455	0.35320		-0.2950
2 0*e*for-mom			218.09473	0.00006		0.06308	0.07559	1.09982	0.35747		-0.2984
network id:		index:	2 source	source type = 0	doublet	doublet type = 12	numbe	number rows = 8	number	columns =	œ
jc ip	×	≻	2	90	ģ	ďλ	dz	08	anx	any	ø
lmachu	wxn	πλm	wzw	pheu	vxu	n	nzn	cplinu	cpslnu	cp2ndu	cpi
lmachl	wxl	wyl	wzl	phel	vxl	vyl	vzl	cplinl	cpslnl	cp2ndl	cpi
snt wnu snd	wnl	numd	pwn1	vtu	vtl	pvtu	pvtl	cplind	cpslnd	cp2ndd	cpi
112 65	43.9301	-2.9497	-3.8857	-0.3830	0.0239	0.1109	0.1332	0.000	0.0000	0.0234	0-
0.7810	0.9895	0.0571	0.0684	-1.0960	0.9741	0.0571	0.0679	0.0483	0.0439	0.0437	0
0.7609	0.9839	-0.0538	-0.0641	-0.7130	0.9501	-0.0538	-0.0653	0.1054	0.0928	0.0918	0
0.0000	0.0000	0.0222	0.0222	0.9781	0.9539	0.0669	0.1218	-0.0571	-0.0489	-0.0481	0 -
113 66	41.3597	-2.9495	-3,8858	-0.4581	0.0263	0.0643	0.0775	0.0000	0.0000	0.0234	0 -
0.7883	0.9942	0.0345	0.0412	-1.0532	0.9853	0.0345	0.0409	0.0278	0.0266	0.0265	0
0.7655	0.9864	-0.0298	-0.0356	-0.5950	0.9590	-0.0298	-0.0366	0.0857	0.0800	0.0793	0
0.0000 0.0526	0.0000	0.0224	0.0224	0.9867	0.9601	0.0302	0.0842	-0.0579	-0.0534	-0.0528	0
114 67	38.7894	-2.9495	-3.8858	-0.5064	0.0122	0.0308	0.0371	0.0000	0.0000	0.0234	0-
0.7849	0.9936	0.0181	0.0216	-1.0143	0.9826	0.0181	0.0212	0.0345	0.0340	0.0339	0
0.7743	0.9901	-0.0127	-0.0152	-0.5079	0.9705	-0.0127	-0.0159	0.0614	0.0587	0.0584	0
0.0000	0.0000	0.0224	0.0224	0.9830	0.9707	0.0168	0.0553	-0.0269	-0.0248	-0.0245	0
115 68	36.2197	-2.9493	-3.8859	-0.5195	-0.0020	0.0076	0.0091	0.0000	0.0000	0.0234	0-
0.7800	0.9921	0.0066	0.0081	-0.9653	0.9774	0.0066	0.0076	0.0459	0.0451	0.0449	o

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